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# A Computer Program for Counting Load Spectrum Cycles based on the Range Pair Cycle Counting Method

V. A. Tischler

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## FOREWORD

This report was prepared by V.A. Tischler of the Solid Mechanics Branch, Structures Division, Air Force Flight Dynamics Laboratory. The work was conducted in-house under Project 1467, "Structural Analysis Methods," Task 146702, "Analysis Methods for Damaged Structures". Mr. Howard A. Wood is the Project Engineer.

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This technical memorandum has been reviewed and is approved.

FRANCIS J. JANIK, JR.
Chief, Solid Mechanics Branch
Structures Division

ABSTRACT

This report presents a detailed description of a computer program based on the Range Pair Cycle Counting Method, as given in Reference 3. The Range Pair Cycle Counting Method is a procedure for generating an analysis spectrum from a given load spectrum. Examples are presented where the resulting analysis spectrum will be used as input to a crack growth analysis program.

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## SECTION I

## INTRODUCTION

In crack propagation analysis it is necessary to have a correct representation of the load spectrum. A load spectrum obtained from tests may not be directly applicable to analysis. The Range Pair Cycle Counting Method is a means of determining an accurate analysis spectrum from the actual load spectrum. This method is briefly discussed and compared with other counting methods in References 1 and 2. A more comprehensive discussion which forms the basis for the development of the present computer program is given in Reference 3.

The computer program treats a load spectrum S as a collection of n peaks and valleys designated by $x_i$, $i = 1,\ldots,2n$, such that if $x_j$ is a peak then $x_{j+1}$ is a valley, $1 \leq j \leq 2n-1$. The analysis spectrum is represented by a collection of m cycles $\{(a,b)_i\}$, $i = 1,\ldots,m$, such that $a_i$ and $b_i$ are elements of S. The Range Pair Cycle Counting Method considers four points $(x_1,x_2,x_3,x_4)$ at a time and the conditions for counting a cycle $(x_2,x_3)$ are as follows:

If $x_2 > x_1$, then a cycle is counted if

$$x_2 \leq x_4 \text{ and } x_3 \geq x_1.$$

Conversely, if $x_2 < x_1$, then a cycle is counted if

$$x_2 \geq x_4 \text{ and } x_3 \leq x_1.$$

This method is illustrated in Figure 1.

Thus, starting at the beginning of the load spectrum the first four points $x_1$, $x_2$, $x_3$ and $x_4$ are considered. If $x_2$ and $x_3$ meet the above conditions, a cycle is defined and these two points are deleted from the spectrum. Consequently $x_4$ becomes $x_2$ and the next two points of the spectrum are added to again give four points. Counting continues until the four points considered do not define a cycle. Then $x_1$ is omitted from consideration and becomes an element of a residue spectrum. The three remaining points are updated, i.e. $x_2$ becomes $x_1$, $x_3$ becomes $x_2$, $x_4$ becomes $x_3$, and $x_4$ is added sequentially from the load spectrum. This process continues until there are only two or three points remaining. These points are added to the residue spectrum, which is then analyzed in the same manner as the original load spectrum. Continuing in this manner a residue spectrum is

finally generated which will yield no cycles by the Range Pair Cycle Counting Method. This residue spectrum diverges to a maximum range and then converges as shown in Figure 2. Cycles are generated from the final residue spectrum as follows: Pair the highest peak with the lowest valley to form a cycle. Then moving away from this cycle in both directions, each successive peak and valley are paired together. If there is an extra peak or valley left on either side, it is omitted. This counting method is illustrated in Figure 2.

In summary, an original load spectrum is analyzed using the Range Pair Cycle Counting Method to produce an analysis spectrum plus a final residue spectrum. This final residue spectrum is then analyzed by a pairing technique to determine the remaining cycles, which are then added to those previously counted. The result is a complete analysis spectrum for use in analytical predictions.

## SECTION II

## PROGRAM ORGANIZATION

The Range Pair Cycle Counting program, RPCM, assumes that the input load spectrum, S, is defined by n peaks and valleys, $(x_i,y_i)$, and n counters $k_i$, $i=1,\ldots,n$, where $k_i$ is a count of the number of times the ith peak and valley are to be repeated sequentially. The program then assigns a step number j, $j=1,\ldots,n$ to each peak and valley of S. Since the analysis spectrum is generated in disjoint parts, i.e. from the input load spectrum, from each residue spectrum, and from the final residue spectrum, the step numbers are used to sort the analysis spectrum relative to the sequencing of the initial load spectrum. Sequence becomes important particularly in crack growth analysis. When the counter k is less than 1, as can occur in a flight by flight load spectrum, the peak and valley associated with k is not analyzed by the program, but is transferred directly into the analysis spectrum and subsequently sequenced relative to its step number.

The program RPCM is divided into three parts. Each part is described below in a step-by-step manner.

### Part I

1. The initial load spectrum S is adjusted by removing those peaks and valleys whose counter k is less than one.

2. The initial load spectrum S is further adjusted if for some i, the ith peak and valley are equal to the (i+1)th peak and valley, by maximizing the counter $k_i$.

3. The Range Pair Cycle Counting Method is now applied to the adjusted load spectrum, S. Program RPCM calls Subroutine DECIDE with four elements from S. Subroutine DECIDE determines whether a cycle is to be generated or whether $x_1$ goes to the residue spectrum. Cycles are generated in Subroutine CYCGEN.

### Part II

1. The Range Pair Cycle Counting Method is applied to the residue spectrum. Program RPCM calls Subroutine DECRES with four elements from the residue spectrum. Subroutine DECRES determines whether a cycle is to be generated or whether $x_1$ goes to the next residue spectrum. Cycles are generated in Subroutine CYCRES.

2. If the current residue spectrum has less than three points or if no additional cycles can be generated by the Range Pair Cycle Counting Method, proceed to Part III, otherwise return to Step 1.

Part III

1. The remaining cycles are generated from the final residue spectrum.

2. The analysis spectrum is sorted relative to the sequencing of the input load spectrum.

# SECTION III

## INPUT INSTRUCTIONS

| Card No. (Format) | Variable Name | Definition |
|---|---|---|
| 1 (8A10) | TITLE | An alphanumeric description of the load spectrum, S |
| 2 (2I5) | NPKS | Number of peaks or valleys in the load spectrum, S |
| | NPUNCH | Punch flag<br>NPUNCH ≠ 0 implies the analysis spectrum will be punched in the input format. |
| 3,...,NPKS+2 (5x,3E10.3) | SIGMAX(I) | Ith peak of the load spectrum, S |
| | SIGMIN(I) | Ith valley of the load spectrum, S |
| | RNCYC(I) | counter $k_i$ of the Ith peak and valley |

## SECTION IV

## TABULAR OUTPUT

Program RPCM gives the following output:

1. The input load spectrum, S.

2. The adjusted load spectrum as discussed in Section II.

3. The elements and step numbers of Residue Spectrum 1.

4. The elements, the step number and the counter k of the cycles generated from the adjusted load spectrum.

5. The elements and step numbers of Residue Spectrum 2.

6. Step 4 output is repeated plus any additional cycle information generated from Residue Spectrum 1.

7. Steps 5 and 6 are repeated for each residue spectrum until the final residue spectrum is generated.

8. All previous cycle output plus any additional cycle information generated from the final residue spectrum.

9. The Range Pair Cycle Counted spectrum, i.e., the analysis spectrum.

## REFERENCES

1. J.B. de Jonge, "The Monitoring of Fatigue Loads," National Aerospace Laboratory NLR, The Netherlands, Report MP 70010 U.

2. N.E. Dowling, "Fatigue Failure Predictions for Complicated Stress - Strain Histories", University of Illinois, Urbana, T.&A.M., Report No. 337, January 1971.

3. S. Streitmatter, "A Method of Counting Spectrum Load Cycles", North American Rockwell, Los Angeles Division, TFD-72-358, March 1972.

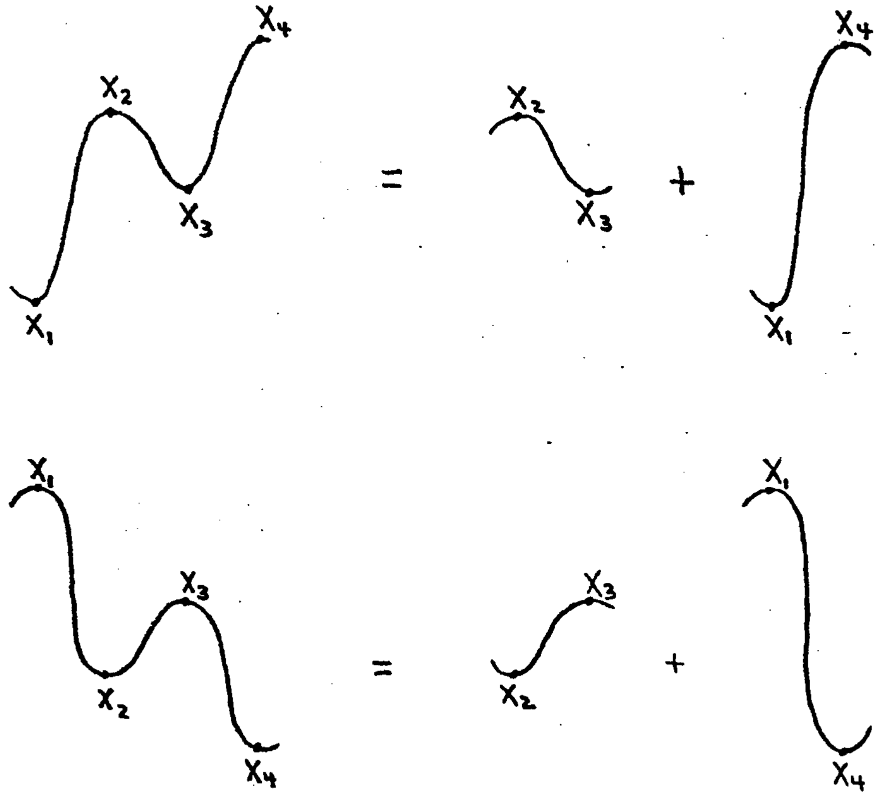



Figure 1

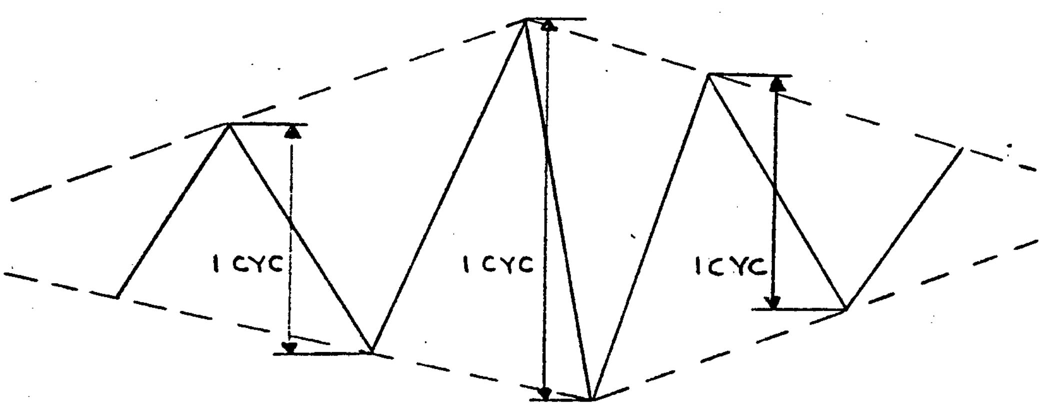



Figure 2

PARTIAL SCHEMATIC OF THE 14 MISSION C5-A A SPECTRUM

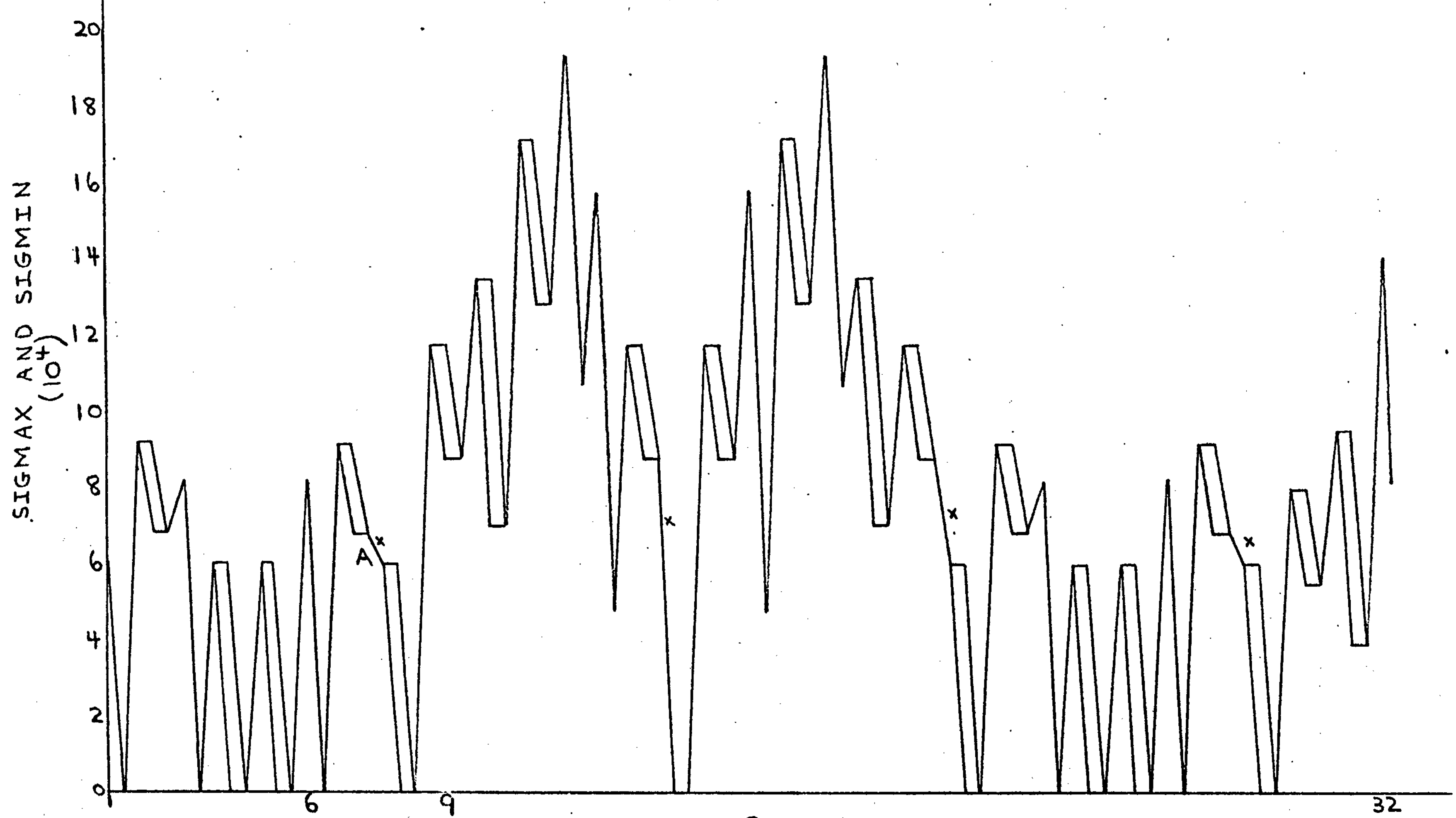



Figure 3

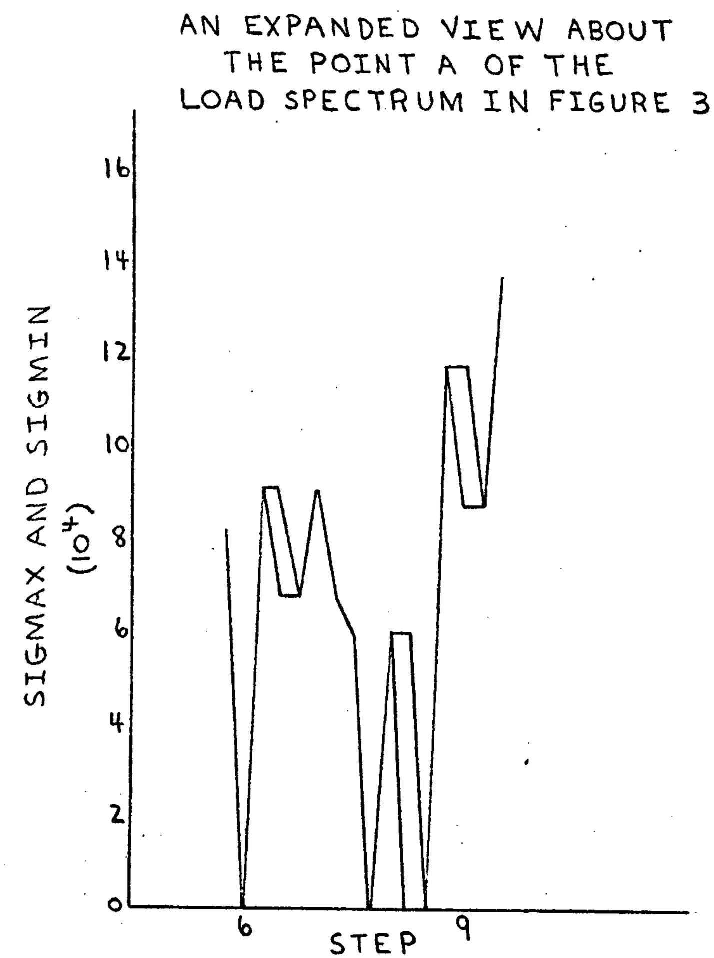

AN EXPANDED VIEW ABOUT
THE POINT A OF THE
LOAD SPECTRUM IN FIGURE 3
SIGMAX AND SIGMIN
(10^4)
16
14
12
10
8
6
4
2
0
6
STEP
9

Figure 4

APPENDIX I

SAMPLE PROBLEMS

1. <u>14 Mission C5-A A Spectrum</u>

A partial plot of the input load spectrum S is given in Figure 3. The full spectrum is listed on P . It has been observed that the spectrum listing may not be a good representation of the load spectrum since some of the peaks or valley values given in the spectrum listing do not match the actual peaks and valleys on the load spectrum. This can be illustrated by steps 6 through 9 of the spectrum listing.

| | | | |
|---|---|---|---|
| 6 | 8215.0 | 0.0 | 1 |
| 7 | 9146.0 | 6846.0 | 5 |
| 8 | 6065.0 | 0.0 | 12 |
| 9 | 11790.0 | 8790.0 | 50 |

The load spectrum that these 4 steps would produce is given in Figure 4. Now considering the actual peaks and valleys shown in Figure 4, steps 6 through 9 should become

| | | |
|---|---|---|
| 8215.0 | 0.0 | 1 |
| 9146.0 | 6846.0 | 4 |
| 9146.0 | 0.0 | 1 |
| 6065.0 | 0.0 | 11 |
| 11790.0 | 8790.0 | 50 |

These five steps may now be range pair counted according to the rules given. The x's on Figure 3 indicate additional places where the above type of behaviour occurs.

The program as written can handle such discrepancies in the initial load spectrum.

14 MISSION C5-A A SPECTRUM

THE NUMBER OF PEAKS OR VALLEYS IN THE INPUT LOAD SPECTRUM = 78

| STEP | SIGMA MAXIMUM | SIGMA MINIMUM | COUNTER K |
|---|---|---|---|
| 1 | .606500E+04 | 0. | 12.00000 |
| 2 | .914600E+04 | .684600E+04 | 5.00000 |
| 3 | .821500E+04 | 0. | 1.00000 |
| 4 | .606500E+04 | 0. | 12.00000 |
| 5 | .606500E+04 | 0. | 12.00000 |
| 6 | .821500E+04 | 0. | 1.00000 |
| 7 | .914600E+04 | .684600E+04 | 5.00000 |
| 8 | .606500E+04 | 0. | 12.00000 |
| 9 | .117900E+05 | .879000E+04 | 50.00000 |
| 10 | .135400E+05 | .704000E+04 | 29.00000 |
| 11 | .172000E+05 | .129000E+05 | 14.00000 |
| 12 | .194000E+05 | .107300E+05 | 1.00000 |
| 13 | .157900E+05 | .479000E+04 | 1.00000 |
| 14 | .117900E+05 | .879000E+04 | 50.00000 |
| 15 | .100000E+01 | 0. | 1.00000 |
| 16 | .117900E+05 | .879000E+04 | 50.00000 |
| 17 | .157900E+05 | .479000E+04 | 1.00000 |
| 18 | .172000E+05 | .129000E+05 | 14.00000 |
| 19 | .194000E+05 | .107300E+05 | 1.00000 |
| 20 | .135400E+05 | .704000E+04 | 29.00000 |
| 21 | .117900E+05 | .879000E+04 | 50.00000 |
| 22 | .606500E+04 | 0. | 12.00000 |
| 23 | .914600E+04 | .684600E+04 | 5.00000 |
| 24 | .821500E+04 | 0. | 1.00000 |
| 25 | .606500E+04 | 0. | 12.00000 |
| 26 | .606500E+04 | 0. | 12.00000 |
| 27 | .821500E+04 | 0. | 1.00000 |
| 28 | .914600E+04 | .684600E+04 | 5.00000 |
| 29 | .606500E+04 | 0. | 12.00000 |
| 30 | .794700E+04 | .544700E+04 | 50.00000 |
| 31 | .949700E+04 | .389700E+04 | 24.00000 |
| 32 | .140000E+05 | .810000E+04 | 1.00000 |
| 33 | .122500E+05 | .985000E+04 | 24.00000 |
| 34 | .113970E+05 | .199700E+04 | 1.00000 |
| 35 | .794700E+04 | .544700E+04 | 50.00000 |
| 36 | .606500E+04 | 0. | 12.00000 |
| 37 | .914600E+04 | .684600E+04 | 5.00000 |
| 38 | .821500E+04 | 0. | 1.00000 |
| 39 | .606500E+04 | 0. | 12.00000 |
| 40 | .606500E+04 | 0. | 12.00000 |
| 41 | .821500E+04 | 0. | 1.00000 |
| 42 | .914600E+04 | .684600E+04 | 5.00000 |
| 43 | .606500E+04 | 0. | 12.00000 |
| 44 | .794700E+04 | .544700E+04 | 50.00000 |
| 45 | .113970E+05 | .199700E+04 | 1.00000 |
| 46 | .122500E+05 | .985000E+04 | 24.00000 |
| 47 | .140000E+05 | .810000E+04 | 1.00000 |
| 48 | .949700E+04 | .389700E+04 | 24.00000 |
| 49 | .794700E+04 | .544700E+04 | 50.00000 |
| 50 | .606500E+04 | 0. | 12.00000 |
| 51 | .914600E+04 | .684600E+04 | 5.00000 |
| 52 | .821500E+04 | 0. | 1.00000 |
| 53 | .606500E+04 | 0. | 12.00000 |
| 54 | .606500E+04 | 0. | 12.00000 |

| | | | |
|---|---|---|---|
| 55 | .821500E+04 | 0. | 1.00000 |
| 56 | .914600E+04 | .684600E+04 | 5.00000 |
| 57 | .606500E+04 | 0. | 12.00000 |
| 58 | .117900E+05 | .879000E+04 | 50.00000 |
| 59 | .135400E+05 | .704000E+04 | 29.00000 |
| 60 | .172000E+05 | .129000E+05 | 14.00000 |
| 61 | .194000E+05 | .107000E+05 | 1.00000 |
| 62 | .157900E+05 | .479000E+04 | 1.00000 |
| 63 | .117900E+05 | .879000E+04 | 50.00000 |
| 64 | .100000E+01 | 0. | 1.00000 |
| 65 | .117900E+05 | .879000E+04 | 50.00000 |
| 66 | .157900E+05 | .479000E+04 | 1.00000 |
| 67 | .172000E+05 | .129000E+05 | 14.00000 |
| 68 | .194000E+05 | .107000E+05 | 1.00000 |
| 69 | .135400E+05 | .704000E+04 | 29.00000 |
| 70 | .117900E+05 | .879000E+04 | 50.00000 |
| 71 | .606500E+04 | 0. | 12.00000 |
| 72 | .914600E+04 | .684600E+04 | 5.00000 |
| 73 | .821500E+04 | 0. | 1.00000 |
| 74 | .606500E+04 | 0. | 12.00000 |
| 75 | .606500E+04 | 0. | 12.00000 |
| 76 | .821500E+04 | 0. | 1.00000 |
| 77 | .914600E+04 | .684600E+04 | 5.00000 |
| 78 | .606500E+04 | 0. | 12.00000 |

STEP NUMBERS OF IDENTICAL PEAKS AND VALLEYS WHICH OCCUR CONSECUTIVELY IN THE LOAD SPECTRUM

5 26 40 54 75

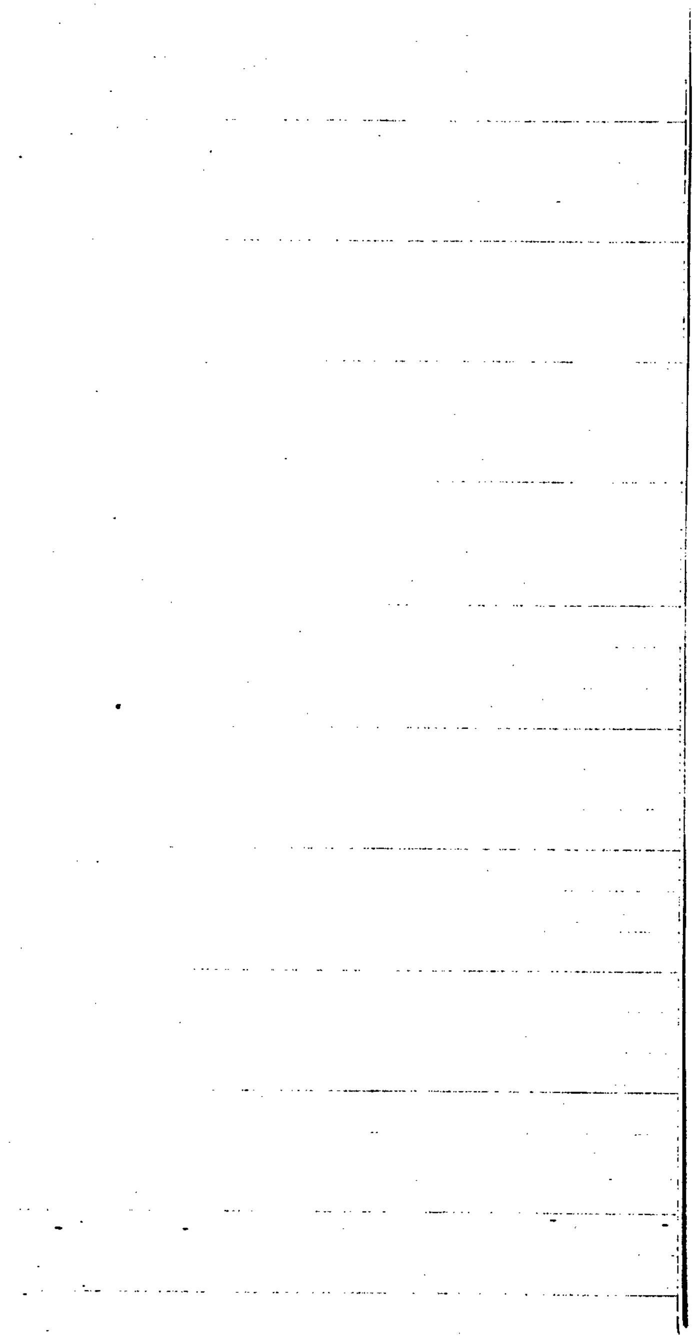
LOAD SPECTRUM DATA ADJUSTED FOR RANGE PAIR COUNTING = 73

| STEP | SIGMA MAXIMUM | SIGMA MINIMUM | COUNTER K |
|---|---|---|---|
| 1 | .606500E+04 | 0. | 12.00000 |
| 2 | .914600E+04 | .684600E+04 | 5.00000 |
| 3 | .821500E+04 | 0. | 1.00000 |
| 4 | .606500E+04 | 0. | 24.00000 |
| 6 | .821500E+04 | 0. | 1.00000 |
| 7 | .914600E+04 | .684600E+04 | 5.00000 |
| 8 | .606500E+04 | 0. | 12.00000 |
| 9 | .117900E+05 | .879000E+04 | 50.00000 |
| 10 | .135400E+05 | .704000E+04 | 29.00000 |
| 11 | .172000E+05 | .129000E+05 | 14.00000 |
| 12 | .194000E+05 | .107000E+05 | 1.00000 |
| 13 | .157900E+05 | .479000E+04 | 1.00000 |
| 14 | .117900E+05 | .879000E+04 | 50.00000 |
| 15 | .100000E+01 | 0. | 1.00000 |
| 16 | .117900E+05 | .879000E+04 | 50.00000 |
| 17 | .157900E+05 | .479000E+04 | 1.00000 |
| 18 | .172000E+05 | .129000E+05 | 14.00000 |
| 19 | .194000E+05 | .107000E+05 | 1.00000 |
| 20 | .135400E+05 | .704000E+04 | 29.00000 |
| 21 | .117900E+05 | .879000E+04 | 50.00000 |
| 22 | .606500E+04 | 0. | 12.00000 |
| 23 | .914600E+04 | .684600E+04 | 5.00000 |
| 24 | .821500E+04 | 0. | 1.00000 |
| 25 | .606500E+04 | 0. | 24.00000 |
| 27 | .821500E+04 | 0. | 1.00000 |
| 28 | .914600E+04 | .684600E+04 | 5.00000 |
| 29 | .606500E+04 | 0. | 12.00000 |
| 30 | .794700E+04 | .544700E+04 | 50.00000 |
| 31 | .949700E+04 | .389700E+04 | 24.00000 |
| 32 | .140000E+05 | .810000E+04 | 1.00000 |
| 33 | .122500E+05 | .985000E+04 | 24.00000 |
| 34 | .113970E+05 | .199700E+04 | 1.00000 |
| 35 | .794700E+04 | .544700E+04 | 50.00000 |
| 36 | .606500E+04 | 0. | 12.00000 |
| 37 | .914600E+04 | .684600E+04 | 5.00000 |
| 38 | .821500E+04 | 0. | 1.00000 |
| 39 | .606500E+04 | 0. | 24.00000 |
| 41 | .821500E+04 | 0. | 1.00000 |
| 42 | .914600E+04 | .684600E+04 | 5.00000 |
| 43 | .606500E+04 | 0. | 12.00000 |
| 44 | .794700E+04 | .544700E+04 | 50.00000 |
| 45 | .113970E+05 | .199700E+04 | 1.00000 |
| 46 | .122500E+05 | .985000E+04 | 24.00000 |
| 47 | .140000E+05 | .810000E+04 | 1.00000 |
| 48 | .949700E+04 | .389700E+04 | 24.00000 |
| 49 | .794700E+04 | .544700E+04 | 50.00000 |
| 50 | .606500E+04 | 0. | 12.00000 |
| 51 | .914600E+04 | .684600E+04 | 5.00000 |
| 52 | .821500E+04 | 0. | 1.00000 |
| 53 | .606500E+04 | 0. | 24.00000 |
| 55 | .821500E+04 | 0. | 1.00000 |
| 56 | .914600E+04 | .684600E+04 | 5.00000 |
| 57 | .606500E+04 | 0. | 12.00000 |
| 58 | .117900E+05 | .879000E+04 | 50.00000 |
| 59 | .135400E+05 | .704000E+04 | 29.00000 |
| 60 | .172000E+05 | .129000E+05 | 14.00000 |

| | | | |
|---|---|---|---|
| 61 | .194000E+05 | .107000E+05 | 1.00000 |
| 62 | .157900E+05 | .479000E+04 | 1.00000 |
| 63 | .117900E+05 | .879000E+04 | 50.00000 |
| 64 | .100000E+01 | 0. | 1.00000 |
| 65 | .117900E+05 | .879000E+04 | 50.00000 |
| 66 | .157900E+05 | .479000E+04 | 1.00000 |
| 67 | .172000E+05 | .129000E+05 | 14.00000 |
| 68 | .194000E+05 | .107000E+05 | 1.00000 |
| 69 | .135400E+05 | .704000E+04 | 29.00000 |
| 70 | .117900E+05 | .879000E+04 | 50.00000 |
| 71 | .606500E+04 | 0. | 12.00000 |
| 72 | .914600E+04 | .684600E+04 | 5.00000 |
| 73 | .821500E+04 | 0. | 1.00000 |
| 74 | .606500E+04 | 0. | 24.00000 |
| 76 | .821500E+04 | 0. | 1.00000 |
| 77 | .914600E+04 | .684600E+04 | 5.00000 |
| 78 | .606500E+04 | 0. | 12.00000 |

MEMBERS OF RESIDUE SPECTRUM 1 = 48

| VALUE | STEP |
|---|---|
| .506500E+04 | 1 |
| 0. | 1 |
| .914600E+04 | 2 |
| 0. | 6 |
| .914600E+04 | 7 |
| 0. | 8 |
| .194000E+05 | 12 |
| .479000E+04 | 13 |
| .117900E+05 | 14 |
| 0. | 15 |
| .194000E+05 | 19 |
| .704000E+04 | 20 |
| .117900E+05 | 21 |
| 0. | 22 |
| .914600E+04 | 23 |
| 0. | 27 |
| .914600E+04 | 28 |
| 0. | 29 |
| .140000E+05 | 32 |
| .310000E+04 | 32 |
| .122500E+05 | 33 |
| .199700E+04 | 34 |
| .794700E+04 | 35 |
| 0. | 36 |
| .914600E+04 | 37 |
| 0. | 41 |
| .914600E+04 | 42 |
| 0. | 43 |
| .140000E+05 | 47 |
| .389700E+04 | 48 |
| .794700E+04 | 49 |
| 0. | 50 |
| .914600E+04 | 51 |
| 0. | 55 |
| .914600E+04 | 56 |
| 0. | 57 |
| .194000E+05 | 61 |
| .479000E+04 | 62 |
| .117900E+05 | 63 |
| 0. | 64 |
| .194000E+05 | 68 |
| .704000E+04 | 69 |
| .117900E+05 | 70 |
| 0. | 71 |
| .914600E+04 | 72 |
| 0. | 76 |
| .914600E+04 | 77 |
| 0. | 78 |



CYCLES GENERATED BEFORE RESIDUE SPECTRUM 1 = 68

| STEP | SIGMA MAXIMUM | SIGMA MINIMUM | COUNTER K |
|---|---|---|---|
| 1 | .606500E+04 | 0. | 11.00000 |
| 2 | .914600E+04 | .684600E+04 | 4.00000 |
| 3 | .821500E+04 | .684600E+04 | 1.00000 |
| 4 | .606500E+04 | 0. | 24.00000 |
| 6 | .821500E+04 | 0. | 1.00000 |
| 7 | .914600E+04 | .684600E+04 | 4.00000 |
| 8 | .606500E+04 | 0. | 11.00000 |
| 9 | .117900E+05 | .879000E+04 | 50.00000 |
| 10 | .135400E+05 | .704000E+04 | 29.00000 |
| 11 | .172000E+05 | .129000E+05 | 14.00000 |
| 13 | .157900E+05 | .107000E+05 | 1.00000 |
| 14 | .117900E+05 | .879000E+04 | 99.00000 |
| 18 | .157900E+05 | .479000E+04 | 1.00000 |
| 18 | .172000E+05 | .129000E+05 | 14.00000 |
| 20 | .135400E+05 | .107000E+05 | 1.00000 |
| 20 | .135400E+05 | .704000E+04 | 28.00000 |
| 21 | .117900E+05 | .879000E+04 | 49.00000 |
| 22 | .606500E+04 | 0. | 11.00000 |
| 23 | .914600E+04 | .684600E+04 | 4.00000 |
| 24 | .821500E+04 | .684600E+04 | 1.00000 |
| 25 | .606500E+04 | 0. | 24.00000 |
| 27 | .821500E+04 | 0. | 1.00000 |
| 28 | .914600E+04 | .684600E+04 | 4.00000 |
| 29 | .606500E+04 | 0. | 11.00000 |
| 30 | .794700E+04 | .544700E+04 | 50.00000 |
| 31 | .949700E+04 | .389700E+04 | 24.00000 |
| 33 | .122500E+05 | .985000E+04 | 23.00000 |
| 34 | .113970E+05 | .985000E+04 | 1.00000 |
| 35 | .794700E+04 | .544700E+04 | 49.00000 |
| 36 | .606500E+04 | .544700E+04 | 1.00000 |
| 36 | .606500E+04 | 0. | 11.00000 |
| 37 | .914600E+04 | .684600E+04 | 4.00000 |
| 38 | .821500E+04 | .684600E+04 | 1.00000 |
| 39 | .606500E+04 | 0. | 24.00000 |
| 41 | .821500E+04 | 0. | 1.00000 |
| 42 | .914600E+04 | .684600E+04 | 4.00000 |
| 43 | .606500E+04 | 0. | 11.00000 |
| 44 | .794700E+04 | .544700E+04 | 50.00000 |
| 46 | .113970E+05 | .199700E+04 | 1.00000 |
| 46 | .122500E+05 | .985000E+04 | 24.00000 |
| 48 | .949700E+04 | .810000E+04 | 1.00000 |
| 48 | .949700E+04 | .389700E+04 | 23.00000 |
| 49 | .794700E+04 | .544700E+04 | 49.00000 |
| 50 | .606500E+04 | .544700E+04 | 1.00000 |
| 50 | .606500E+04 | 0. | 11.00000 |
| 51 | .914600E+04 | .684600E+04 | 4.00000 |
| 52 | .821500E+04 | .684600E+04 | 1.00000 |
| 53 | .606500E+04 | 0. | 24.00000 |
| 55 | .821500E+04 | 0. | 1.00000 |
| 56 | .914600E+04 | .684600E+04 | 4.00000 |
| 57 | .606500E+04 | 0. | 11.00000 |
| 58 | .117900E+05 | .879000E+04 | 50.00000 |
| 59 | .135400E+05 | .704000E+04 | 29.00000 |
| 60 | .172000E+05 | .129000E+05 | 14.00000 |
| 62 | .157900E+05 | .107000E+05 | 1.00000 |
| 63 | .117900E+05 | .879000E+04 | 99.00000 |

| | | | |
|---|---|---|---|
| 67 | .157900E+05 | .479000E+04 | 1.00000 |
| 67 | .172000E+05 | .129000E+05 | 14.00000 |
| 69 | .135400E+05 | .107000E+05 | 1.00000 |
| 69 | .135400E+05 | .704000E+04 | 28.00000 |
| 70 | .117900E+05 | .879000E+04 | 49.00000 |
| 71 | .606500E+04 | 0. | 11.00000 |
| 72 | .914600E+04 | .684600E+04 | 4.00000 |
| 73 | .821500E+04 | .684600E+04 | 1.00000 |
| 74 | .606500E+04 | 0. | 24.00000 |
| 76 | .821500E+04 | 0. | 1.00000 |
| 77 | .914600E+04 | .684600E+04 | 4.00000 |
| 78 | .606500E+04 | 0. | 11.00000 |

MEMBERS OF RESIDUE SPECTRUM 2 = 14

| VALUE | STEP |
|---|---|
| .506500E+04 | 1 |
| 0. | 1 |
| .194000E+05 | 12 |
| 0. | 15 |
| .194000E+05 | 19 |
| 0. | 29 |
| .140000E+05 | 32 |
| 0. | 43 |
| .140000E+05 | 47 |
| 0. | 57 |
| .194000E+05 | 61 |
| 0. | 64 |
| .194000E+05 | 68 |
| 0. | 78 |

CYCLES GENERATED BEFORE RESIDUE SPECTRUM 2 = 85

| STEP | SIGMA MAXIMUM | SIGMA MINIMUM | COUNTER K |
|---|---|---|---|
| 1 | .606500E+04 | 0. | 11.00000 |
| 2 | .914600E+04 | .684600E+04 | 4.00000 |
| 3 | .821500E+04 | .684600E+04 | 1.00000 |
| 4 | .606500E+04 | 0. | 24.00000 |
| 6 | .821500E+04 | 0. | 1.00000 |
| 7 | .914600E+04 | .684600E+04 | 4.00000 |
| 8 | .606500E+04 | 0. | 11.00000 |
| 9 | .117900E+05 | .879000E+04 | 50.00000 |
| 10 | .135400E+05 | .704000E+04 | 29.00000 |
| 11 | .172000E+05 | .129000E+05 | 14.00000 |
| 13 | .157900E+05 | .107000E+05 | 1.00000 |
| 14 | .117900E+05 | .879000E+04 | 99.00000 |
| 18 | .157900E+05 | .479000E+04 | 1.00000 |
| 18 | .172000E+05 | .129000E+05 | 14.00000 |
| 20 | .135400E+05 | .107000E+05 | 1.00000 |
| 20 | .135400E+05 | .704000E+04 | 28.00000 |
| 21 | .117900E+05 | .879000E+04 | 49.00000 |
| 22 | .606500E+04 | 0. | 11.00000 |
| 23 | .914600E+04 | .684600E+04 | 4.00000 |
| 24 | .821500E+04 | .684600E+04 | 1.00000 |
| 25 | .606500E+04 | 0. | 24.00000 |
| 27 | .821500E+04 | 0. | 1.00000 |
| 28 | .914600E+04 | .684600E+04 | 4.00000 |
| 29 | .606500E+04 | 0. | 11.00000 |
| 30 | .794700E+04 | .544700E+04 | 50.00000 |
| 31 | .949700E+04 | .389700E+04 | 24.00000 |
| 33 | .122500E+05 | .985000E+04 | 23.00000 |
| 34 | .113970E+05 | .985000E+04 | 1.00000 |
| 35 | .794700E+04 | .544700E+04 | 49.00000 |
| 36 | .606500E+04 | .544700E+04 | 1.00000 |
| 36 | .606500E+04 | 0. | 11.00000 |
| 37 | .914600E+04 | .684600E+04 | 4.00000 |
| 38 | .821500E+04 | .684600E+04 | 1.00000 |
| 39 | .606500E+04 | 0. | 24.00000 |
| 41 | .821500E+04 | 0. | 1.00000 |
| 42 | .914600E+04 | .684600E+04 | 4.00000 |
| 43 | .606500E+04 | 0. | 11.00000 |
| 44 | .794700E+04 | .544700E+04 | 50.00000 |
| 46 | .113970E+05 | .199700E+04 | 1.00000 |
| 46 | .122500E+05 | .985000E+04 | 24.00000 |
| 48 | .949700E+04 | .810000E+04 | 1.00000 |
| 48 | .949700E+04 | .389700E+04 | 23.00000 |
| 49 | .794700E+04 | .544700E+04 | 49.00000 |
| 50 | .606500E+04 | .544700E+04 | 1.00000 |
| 50 | .606500E+04 | 0. | 11.00000 |
| 51 | .914600E+04 | .684600E+04 | 4.00000 |
| 52 | .821500E+04 | .684600E+04 | 1.00000 |
| 53 | .606500E+04 | 0. | 24.00000 |
| 55 | .821500E+04 | 0. | 1.00000 |
| 56 | .914600E+04 | .684600E+04 | 4.00000 |
| 57 | .606500E+04 | 0. | 11.00000 |
| 58 | .117900E+05 | .879000E+04 | 50.00000 |
| 59 | .135400E+05 | .704000E+04 | 29.00000 |
| 60 | .172000E+05 | .129000E+05 | 14.00000 |
| 62 | .157900E+05 | .107000E+05 | 1.00000 |
| 63 | .117900E+05 | .879000E+04 | 99.00000 |

| | | | |
|---|---|---|---|
| 67 | .157900E+05 | .479000E+04 | 1.00000 |
| 67 | .172000E+05 | .129000E+05 | 14.00000 |
| 69 | .135400E+05 | .107000E+05 | 1.00000 |
| 69 | .135400E+05 | .704000E+04 | 28.00000 |
| 70 | .117900E+05 | .879000E+04 | 49.00000 |
| 71 | .606500E+04 | 0. | 11.00000 |
| 72 | .914600E+04 | .684600E+04 | 4.00000 |
| 73 | .821500E+04 | .684600E+04 | 1.00000 |
| 74 | .606500E+04 | 0. | 24.00000 |
| 76 | .821500E+04 | 0. | 1.00000 |
| 77 | .914600E+04 | .684600E+04 | 4.00000 |
| 78 | .606500E+04 | 0. | 11.00000 |
| 2 | .914600E+04 | 0. | 1.00000 |
| 7 | .914600E+04 | 0. | 1.00000 |
| 14 | .117900E+05 | .479000E+04 | 1.00000 |
| 21 | .117900E+05 | .704000E+04 | 1.00000 |
| 23 | .914600E+04 | 0. | 1.00000 |
| 28 | .914600E+04 | 0. | 1.00000 |
| 33 | .122500E+05 | .810000E+04 | 1.00000 |
| 35 | .794700E+04 | .199700E+04 | 1.00000 |
| 37 | .914600E+04 | 0. | 1.00000 |
| 42 | .914600E+04 | 0. | 1.00000 |
| 49 | .794700E+04 | .389700E+04 | 1.00000 |
| 51 | .914600E+04 | 0. | 1.00000 |
| 56 | .914600E+04 | 0. | 1.00000 |
| 63 | .117900E+05 | .479000E+04 | 1.00000 |
| 70 | .117900E+05 | .704000E+04 | 1.00000 |
| 72 | .914600E+04 | 0. | 1.00000 |
| 77 | .914600E+04 | 0. | 1.00000 |

MEMBERS OF RESIDUE SPECTRUM 3 = 4

| VALUE | STEP |
|---|---|
| .606500E+04 | 1 |
| 0. | 1 |
| .194000E+05 | 19 |
| 0. | 78 |

CYCLES GENERATED BEFORE RESIDUE SPECTRUM 3 = 90

| STEP | SIGMA MAXIMUM | SIGMA MINIMUM | COUNTER K |
|---|---|---|---|
| 1 | .606500E+04 | 0. | 11.00000 |
| 2 | .914600E+04 | .684600E+04 | 4.00000 |
| 3 | .821500E+04 | .684600E+04 | 1.00000 |
| 4 | .606500E+04 | 0. | 24.00000 |
| 6 | .821500E+04 | 0. | 1.00000 |
| 7 | .914600E+04 | .684600E+04 | 4.00000 |
| 8 | .606500E+04 | 0. | 11.00000 |
| 9 | .117900E+05 | .879000E+04 | 50.00000 |
| 10 | .135400E+05 | .704000E+04 | 29.00000 |
| 11 | .172000E+05 | .129000E+05 | 14.00000 |
| 13 | .157900E+05 | .107000E+05 | 1.00000 |
| 14 | .117900E+05 | .879000E+04 | 99.00000 |
| 18 | .157900E+05 | .479000E+04 | 1.00000 |
| 19 | .172000E+05 | .129000E+05 | 14.00000 |
| 20 | .135400E+05 | .107000E+05 | 1.00000 |
| 20 | .135400E+05 | .704000E+04 | 28.00000 |
| 21 | .117900E+05 | .879000E+04 | 49.00000 |
| 22 | .606500E+04 | 0. | 11.00000 |
| 23 | .914600E+04 | .684600E+04 | 4.00000 |
| 24 | .821500E+04 | .684600E+04 | 1.00000 |
| 25 | .606500E+04 | 0. | 24.00000 |
| 27 | .821500E+04 | 0. | 1.00000 |
| 28 | .914600E+04 | .684600E+04 | 4.00000 |
| 29 | .606500E+04 | 0. | 11.00000 |
| 30 | .794700E+04 | .544700E+04 | 50.00000 |
| 31 | .949700E+04 | .389700E+04 | 24.00000 |
| 33 | .122500E+05 | .985000E+04 | 23.00000 |
| 34 | .113970E+05 | .985000E+04 | 1.00000 |
| 35 | .794700E+04 | .544700E+04 | 49.00000 |
| 36 | .606500E+04 | .544700E+04 | 1.00000 |
| 36 | .606500E+04 | 0. | 11.00000 |
| 37 | .914600E+04 | .684600E+04 | 4.00000 |
| 38 | .821500E+04 | .684600E+04 | 1.00000 |
| 39 | .606500E+04 | 0. | 24.00000 |
| 41 | .821500E+04 | 0. | 1.00000 |
| 42 | .914600E+04 | .684600E+04 | 4.00000 |
| 43 | .606500E+04 | 0. | 11.00000 |
| 44 | .794700E+04 | .544700E+04 | 50.00000 |
| 46 | .113970E+05 | .199700E+04 | 1.00000 |
| 46 | .122500E+05 | .985000E+04 | 24.00000 |
| 48 | .949700E+04 | .810000E+04 | 1.00000 |
| 48 | .949700E+04 | .389700E+04 | 23.00000 |
| 49 | .794700E+04 | .544700E+04 | 49.00000 |
| 50 | .606500E+04 | .544700E+04 | 1.00000 |
| 50 | .606500E+04 | 0. | 11.00000 |
| 51 | .914600E+04 | .684600E+04 | 4.00000 |
| 52 | .821500E+04 | .684600E+04 | 1.00000 |
| 53 | .606500E+04 | 0. | 24.00000 |
| 55 | .821500E+04 | 0. | 1.00000 |
| 56 | .914600E+04 | .684600E+04 | 4.00000 |
| 57 | .606500E+04 | 0. | 11.00000 |
| 58 | .117900E+05 | .879000E+04 | 50.00000 |
| 59 | .135400E+05 | .704000E+04 | 29.00000 |
| 60 | .172000E+05 | .129000E+05 | 14.00000 |
| 62 | .157900E+05 | .107000E+05 | 1.00000 |
| 63 | .117900E+05 | .879000E+04 | 99.00000 |

| | | | |
|---|---|---|---|
| 67 | .157900E+05 | .479000E+04 | 1.00000 |
| 67 | .172000E+05 | .129000E+05 | 14.00000 |
| 69 | .135400E+05 | .107000E+05 | 1.00000 |
| 69 | .135400E+05 | .704000E+04 | 28.00000 |
| 70 | .117900E+05 | .879000E+04 | 49.00000 |
| 71 | .606500E+04 | 0. | 11.00000 |
| 72 | .914600E+04 | .684600E+04 | 4.00000 |
| 73 | .821500E+04 | .684600E+04 | 1.00000 |
| 74 | .606500E+04 | 0. | 24.00000 |
| 76 | .821500E+04 | 0. | 1.00000 |
| 77 | .914600E+04 | .684600E+04 | 4.00000 |
| 78 | .606500E+04 | 0. | 11.00000 |
| 2 | .914600E+04 | 0. | 1.00000 |
| 7 | .914600E+04 | 0. | 1.00000 |
| 14 | .117900E+05 | .479000E+04 | 1.00000 |
| 21 | .117900E+05 | .704000E+04 | 1.00000 |
| 23 | .914600E+04 | 0. | 1.00000 |
| 28 | .914600E+04 | 0. | 1.00000 |
| 33 | .122500E+05 | .810000E+04 | 1.00000 |
| 35 | .794700E+04 | .199700E+04 | 1.00000 |
| 37 | .914600E+04 | 0. | 1.00000 |
| 42 | .914600E+04 | 0. | 1.00000 |
| 49 | .794700E+04 | .389700E+04 | 1.00000 |
| 51 | .914600E+04 | 0. | 1.00000 |
| 56 | .914600E+04 | 0. | 1.00000 |
| 63 | .117900E+05 | .479000E+04 | 1.00000 |
| 70 | .117900E+05 | .704000E+04 | 1.00000 |
| 72 | .914600E+04 | 0. | 1.00000 |
| 77 | .914600E+04 | 0. | 1.00000 |
| 12 | .194000E+05 | 0. | 1.00000 |
| 32 | .140000E+05 | 0. | 1.00000 |
| 47 | .140000E+05 | 0. | 1.00000 |
| 61 | .194000E+05 | 0. | 1.00000 |
| 68 | .194000E+05 | 0. | 1.00000 |

MEMBERS OF RESIDUE SPECTRUM 4 = 4

| VALUE | STEP |
|---|---|
| .606500E+04 | 1 |
| 0. | 1 |
| .194000E+05 | 19 |
| 0. | 78 |

CYCLES GENERATED BEFORE RESIDUE SPECTRUM 4 = 90

| STEP | SIGMA MAXIMUM | SIGMA MINIMUM | COUNTER K |
|---|---|---|---|
| 1 | .606500E+04 | 0. | 11.00000 |
| 2 | .914600E+04 | .684600E+04 | 4.00000 |
| 3 | .821500E+04 | .684600E+04 | 1.00000 |
| 4 | .606500E+04 | 0. | 24.00000 |
| 6 | .821500E+04 | 0. | 1.00000 |
| 7 | .914600E+04 | .684600E+04 | 4.00000 |
| 8 | .606500E+04 | 0. | 11.00000 |
| 9 | .117900E+05 | .879000E+04 | 50.00000 |
| 10 | .135400E+05 | .704000E+04 | 29.00000 |
| 11 | .172000E+05 | .129000E+05 | 14.00000 |
| 13 | .157900E+05 | .107000E+05 | 1.00000 |
| 14 | .117900E+05 | .879000E+04 | 99.00000 |
| 18 | .157900E+05 | .479000E+04 | 1.00000 |
| 18 | .172000E+05 | .129000E+05 | 14.00000 |
| 20 | .135400E+05 | .107000E+05 | 1.00000 |
| 20 | .135400E+05 | .704000E+04 | 28.00000 |
| 21 | .117900E+05 | .879000E+04 | 49.00000 |
| 22 | .606500E+04 | 0. | 11.00000 |
| 23 | .914600E+04 | .684600E+04 | 4.00000 |
| 24 | .821500E+04 | .684600E+04 | 1.00000 |
| 25 | .606500E+04 | 0. | 24.00000 |
| 27 | .821500E+04 | 0. | 1.00000 |
| 28 | .914600E+04 | .684600E+04 | 4.00000 |
| 29 | .606500E+04 | 0. | 11.00000 |
| 30 | .794700E+04 | .544700E+04 | 50.00000 |
| 31 | .949700E+04 | .389700E+04 | 24.00000 |
| 33 | .122500E+05 | .985000E+04 | 23.00000 |
| 34 | .113970E+05 | .985000E+04 | 1.00000 |
| 35 | .794700E+04 | .544700E+04 | 49.00000 |
| 36 | .606500E+04 | .544700E+04 | 1.00000 |
| 36 | .606500E+04 | 0. | 11.00000 |
| 37 | .914600E+04 | .684600E+04 | 4.00000 |
| 38 | .821500E+04 | .684600E+04 | 1.00000 |
| 39 | .606500E+04 | 0. | 24.00000 |
| 41 | .821500E+04 | 0. | 1.00000 |
| 42 | .914600E+04 | .684600E+04 | 4.00000 |
| 43 | .606500E+04 | 0. | 11.00000 |
| 44 | .794700E+04 | .544700E+04 | 50.00000 |
| 46 | .113970E+05 | .199700E+04 | 1.00000 |
| 46 | .122500E+05 | .985000E+04 | 24.00000 |
| 48 | .949700E+04 | .810000E+04 | 1.00000 |
| 48 | .949700E+04 | .389700E+04 | 23.00000 |
| 49 | .794700E+04 | .544700E+04 | 49.00000 |
| 50 | .606500E+04 | .544700E+04 | 1.00000 |
| 50 | .606500E+04 | 0. | 11.00000 |
| 51 | .914600E+04 | .684600E+04 | 4.00000 |
| 52 | .821500E+04 | .684600E+04 | 1.00000 |
| 53 | .606500E+04 | 0. | 24.00000 |
| 55 | .821500E+04 | 0. | 1.00000 |
| 56 | .914600E+04 | .684600E+04 | 4.00000 |
| 57 | .606500E+04 | 0. | 11.00000 |
| 58 | .117900E+05 | .879000E+04 | 50.00000 |
| 59 | .135400E+05 | .704000E+04 | 29.00000 |
| 60 | .172000E+05 | .129000E+05 | 14.00000 |
| 62 | .157900E+05 | .107000E+05 | 1.00000 |
| 63 | .117900E+05 | .879000E+04 | 99.00000 |

| | | | |
|---|---|---|---|
| 67 | .157900E+05 | .479000E+04 | 1.00000 |
| 67 | .172000E+05 | .129000E+05 | 14.00000 |
| 69 | .135400E+05 | .107000E+05 | 1.00000 |
| 69 | .135400E+05 | .704000E+04 | 28.00000 |
| 70 | .117900E+05 | .879000E+04 | 49.00000 |
| 71 | .606500E+04 | 0. | 11.00000 |
| 72 | .914600E+04 | .684600E+04 | 4.00000 |
| 73 | .821500E+04 | .684600E+04 | 1.00000 |
| 74 | .606500E+04 | 0. | 24.00000 |
| 76 | .821500E+04 | 0. | 1.00000 |
| 77 | .914600E+04 | .684600E+04 | 4.00000 |
| 78 | .606500E+04 | 0. | 11.00000 |
| 2 | .914600E+04 | 0. | 1.00000 |
| 7 | .914600E+04 | 0. | 1.00000 |
| 14 | .117900E+05 | .479000E+04 | 1.00000 |
| 21 | .117900E+05 | .704000E+04 | 1.00000 |
| 23 | .914600E+04 | 0. | 1.00000 |
| 28 | .914600E+04 | 0. | 1.00000 |
| 33 | .122500E+05 | .810000E+04 | 1.00000 |
| 35 | .794700E+04 | .199700E+04 | 1.00000 |
| 37 | .914600E+04 | 0. | 1.00000 |
| 42 | .914500E+04 | 0. | 1.00000 |
| 49 | .794700E+04 | .389700E+04 | 1.00000 |
| 51 | .914600E+04 | 0. | 1.00000 |
| 56 | .914600E+04 | 0. | 1.00000 |
| 63 | .117900E+05 | .479000E+04 | 1.00000 |
| 70 | .117900E+05 | .704000E+04 | 1.00000 |
| 72 | .914600E+04 | 0. | 1.00000 |
| 77 | .914600E+04 | 0. | 1.00000 |
| 12 | .194000E+05 | 0. | 1.00000 |
| 32 | .140000E+05 | 0. | 1.00000 |
| 47 | .140000E+05 | 0. | 1.00000 |
| 61 | .194000E+05 | 0. | 1.00000 |
| 68 | .194000E+05 | 0. | 1.00000 |

CYCLES GENERATED FROM LAST RESIDUE SPECTRUM - NO RANGE PAIR COUNTING = 2

| STEP | SIGMA MAXIMUM | SIGMA MINIMUM | COUNTER K |
|---|---|---|---|
| 1 | .606500E+04 | 0. | 11.00000 |
| 2 | .914600E+04 | .684600E+04 | 4.00000 |
| 3 | .821500E+04 | .684600E+04 | 1.00000 |
| 4 | .606500E+04 | 0. | 24.00000 |
| 6 | .821500E+04 | 0. | 1.00000 |
| 7 | .914600E+04 | .684600E+04 | 4.00000 |
| 8 | .606500E+04 | 0. | 11.00000 |
| 9 | .117900E+05 | .879000E+04 | 50.00000 |
| 10 | .135400E+05 | .704000E+04 | 29.00000 |
| 11 | .172000E+05 | .129000E+05 | 14.00000 |
| 13 | .157900E+05 | .107000E+05 | 1.00000 |
| 14 | .117900E+05 | .879000E+04 | 99.00000 |
| 18 | .157900E+05 | .479000E+04 | 1.00000 |
| 18 | .172000E+05 | .129000E+05 | 14.00000 |
| 20 | .135400E+05 | .107000E+05 | 1.00000 |
| 20 | .135400E+05 | .704000E+04 | 28.00000 |
| 21 | .117900E+05 | .879000E+04 | 49.00000 |
| 22 | .606500E+04 | 0. | 11.00000 |
| 23 | .914600E+04 | .684600E+04 | 4.00000 |
| 24 | .821500E+04 | .684600E+04 | 1.00000 |
| 25 | .606500E+04 | 0. | 24.00000 |
| 27 | .821500E+04 | 0. | 1.00000 |
| 28 | .914600E+04 | .684600E+04 | 4.00000 |
| 29 | .606500E+04 | 0. | 11.00000 |
| 30 | .794700E+04 | .544700E+04 | 50.00000 |
| 31 | .949700E+04 | .389700E+04 | 24.00000 |
| 33 | .122500E+05 | .985000E+04 | 23.00000 |
| 34 | .113970E+05 | .985000E+04 | 1.00000 |
| 35 | .794700E+04 | .544700E+04 | 49.00000 |
| 36 | .606500E+04 | .544700E+04 | 1.00000 |
| 36 | .606500E+04 | 0. | 11.00000 |
| 37 | .914600E+04 | .684600E+04 | 4.00000 |
| 38 | .821500E+04 | .684600E+04 | 1.00000 |
| 39 | .606500E+04 | 0. | 24.00000 |
| 41 | .821500E+04 | 0. | 1.00000 |
| 42 | .914600E+04 | .684600E+04 | 4.00000 |
| 43 | .606500E+04 | 0. | 11.00000 |
| 44 | .794700E+04 | .544700E+04 | 50.00000 |
| 46 | .113970E+05 | .199700E+04 | 1.00000 |
| 46 | .122500E+05 | .985000E+04 | 24.00000 |
| 48 | .949700E+04 | .810000E+04 | 1.00000 |
| 48 | .949700E+04 | .389700E+04 | 23.00000 |
| 49 | .794700E+04 | .544700E+04 | 49.00000 |
| 50 | .606500E+04 | .544700E+04 | 1.00000 |
| 50 | .606500E+04 | 0. | 11.00000 |
| 51 | .914600E+04 | .684600E+04 | 4.00000 |
| 52 | .821500E+04 | .684600E+04 | 1.00000 |
| 53 | .606500E+04 | 0. | 24.00000 |
| 55 | .821500E+04 | 0. | 1.00000 |
| 56 | .914600E+04 | .684600E+04 | 4.00000 |
| 57 | .606500E+04 | 0. | 11.00000 |
| 58 | .117900E+05 | .879000E+04 | 50.00000 |
| 59 | .135400E+05 | .704000E+04 | 29.00000 |
| 60 | .172000E+05 | .129000E+05 | 14.00000 |
| 62 | .157900E+05 | .107000E+05 | 1.00000 |
| 63 | .117900E+05 | .879000E+04 | 99.00000 |
| 67 | .157900E+05 | .479000E+04 | 1.00000 |
| 67 | .172000E+05 | .129000E+05 | 14.00000 |

| | | | |
|---|---|---|---|
| 69 | .135400E+05 | .107000E+05 | 1.00000 |
| 69 | .135400E+05 | .704000E+04 | 28.00000 |
| 70 | .117900E+05 | .879000E+04 | 49.00000 |
| 71 | .606500E+04 | 0. | 11.00000 |
| 72 | .914600E+04 | .684600E+04 | 4.00000 |
| 73 | .821500E+04 | .684600E+04 | 1.00000 |
| 74 | .606500E+04 | 0. | 24.00000 |
| 76 | .821500E+04 | 0. | 1.00000 |
| 77 | .914600E+04 | .684600E+04 | 4.00000 |
| 78 | .606500E+04 | 0. | 11.00000 |
| 2 | .914600E+04 | 0. | 1.00000 |
| 7 | .914600E+04 | 0. | 1.00000 |
| 14 | .117900E+05 | .479000E+04 | 1.00000 |
| 21 | .117900E+05 | .704000E+04 | 1.00000 |
| 23 | .914600E+04 | 0. | 1.00000 |
| 28 | .914600E+04 | 0. | 1.00000 |
| 33 | .122500E+05 | .810000E+04 | 1.00000 |
| 35 | .794700E+04 | .199700E+04 | 1.00000 |
| 37 | .914600E+04 | 0. | 1.00000 |
| 42 | .914600E+04 | 0. | 1.00000 |
| 49 | .794700E+04 | .389700E+04 | 1.00000 |
| 51 | .914600E+04 | 0. | 1.00000 |
| 56 | .914600E+04 | 0. | 1.00000 |
| 63 | .117900E+05 | .479000E+04 | 1.00000 |
| 70 | .117900E+05 | .704000E+04 | 1.00000 |
| 72 | .914600E+04 | 0. | 1.00000 |
| 77 | .914600E+04 | 0. | 1.00000 |
| 12 | .194000E+05 | 0. | 1.00000 |
| 32 | .140000E+05 | 0. | 1.00000 |
| 47 | .140000E+05 | 0. | 1.00000 |
| 61 | .194000E+05 | 0. | 1.00000 |
| 68 | .194000E+05 | 0. | 1.00000 |
| 19 | .194000E+05 | 0. | 1.00000 |
| 1 | .606500E+04 | 0. | 1.00000 |

RANGE PAIR CYCLE COUNTED SPECTRUM

| STEP | SIGMA MAXIMUM | SIGMA MINIMUM | COUNTER K |
|---|---|---|---|
| 1 | .606500E+04 | 0. | 12.00000 |
| 2 | .914600E+04 | .684600E+04 | 4.00000 |
| 3 | .914600E+04 | 0. | 1.00000 |
| 4 | .821500E+04 | .684600E+04 | 1.00000 |
| 5 | .606500E+04 | 0. | 24.00000 |
| 6 | .821500E+04 | 0. | 1.00000 |
| 7 | .914600E+04 | .684600E+04 | 4.00000 |
| 8 | .914600E+04 | 0. | 1.00000 |
| 9 | .606500E+04 | 0. | 11.00000 |
| 10 | .117900E+05 | .879000E+04 | 50.00000 |
| 11 | .135400E+05 | .704000E+04 | 29.00000 |
| 12 | .172000E+05 | .129000E+05 | 14.00000 |
| 13 | .194000E+05 | 0. | 1.00000 |
| 14 | .157900E+05 | .107000E+05 | 1.00000 |
| 15 | .117900E+05 | .879000E+04 | 99.00000 |
| 16 | .117900E+05 | .479000E+04 | 1.00000 |
| 17 | .157900E+05 | .479000E+04 | 1.00000 |
| 18 | .172000E+05 | .129000E+05 | 14.00000 |
| 19 | .194000E+05 | 0. | 1.00000 |
| 20 | .135400E+05 | .107000E+05 | 1.00000 |
| 21 | .135400E+05 | .704000E+04 | 28.00000 |
| 22 | .117900E+05 | .879000E+04 | 49.00000 |
| 23 | .117900E+05 | .704000E+04 | 1.00000 |
| 24 | .606500E+04 | 0. | 11.00000 |
| 25 | .914600E+04 | .684600E+04 | 4.00000 |
| 26 | .914600E+04 | 0. | 1.00000 |
| 27 | .821500E+04 | .684600E+04 | 1.00000 |
| 28 | .606500E+04 | 0. | 24.00000 |
| 29 | .821500E+04 | 0. | 1.00000 |
| 30 | .914600E+04 | .684600E+04 | 4.00000 |
| 31 | .914600E+04 | 0. | 1.00000 |
| 32 | .606500E+04 | 0. | 11.00000 |
| 33 | .794700E+04 | .544700E+04 | 50.00000 |
| 34 | .949700E+04 | .389700E+04 | 24.00000 |
| 35 | .140000E+05 | 0. | 1.00000 |
| 36 | .122500E+05 | .985000E+04 | 23.00000 |
| 37 | .122500E+05 | .810000E+04 | 1.00000 |
| 38 | .113970E+05 | .985000E+04 | 1.00000 |
| 39 | .794700E+04 | .544700E+04 | 49.00000 |
| 40 | .794700E+04 | .199700E+04 | 1.00000 |
| 41 | .606500E+04 | .544700E+04 | 1.00000 |
| 42 | .606500E+04 | 0. | 11.00000 |
| 43 | .914600E+04 | .684600E+04 | 4.00000 |
| 44 | .914600E+04 | 0. | 1.00000 |
| 45 | .821500E+04 | .684600E+04 | 1.00000 |
| 46 | .606500E+04 | 0. | 24.00000 |
| 47 | .821500E+04 | 0. | 1.00000 |
| 48 | .914600E+04 | .684600E+04 | 4.00000 |
| 49 | .914600E+04 | 0. | 1.00000 |
| 50 | .606500E+04 | 0. | 11.00000 |
| 51 | .794700E+04 | .544700E+04 | 50.00000 |
| 52 | .113970E+05 | .199700E+04 | 1.00000 |
| 53 | .122500E+05 | .985000E+04 | 24.00000 |
| 54 | .140000E+05 | 0. | 1.00000 |
| 55 | .949700E+04 | .810000E+04 | 1.00000 |
| 56 | .949700E+04 | .389700E+04 | 23.00000 |

| | | | |
|---|---|---|---|
| 57 | .794700E+04 | .544700E+04 | 49.00000 |
| 58 | .794700E+04 | .389700E+04 | 1.00000 |
| 59 | .606500E+04 | .544700E+04 | 1.00000 |
| 60 | .606500E+04 | 0. | 11.00000 |
| 61 | .914600E+04 | .684600E+04 | 4.00000 |
| 62 | .914600E+04 | 0. | 1.00000 |
| 63 | .821500E+04 | .684600E+04 | 1.00000 |
| 64 | .606500E+04 | 0. | 24.00000 |
| 65 | .821500E+04 | 0. | 1.00000 |
| 66 | .914600E+04 | .684600E+04 | 4.00000 |
| 67 | .914600E+04 | 0. | 1.00000 |
| 68 | .606500E+04 | 0. | 11.00000 |
| 69 | .117900E+05 | .879000E+04 | 50.00000 |
| 70 | .135400E+05 | .704000E+04 | 29.00000 |
| 71 | .172000E+05 | .129000E+05 | 14.00000 |
| 72 | .194000E+05 | 0. | 1.00000 |
| 73 | .157900E+05 | .107000E+05 | 1.00000 |
| 74 | .117900E+05 | .879000E+04 | 99.00000 |
| 75 | .117900E+05 | .479000E+04 | 1.00000 |
| 76 | .157900E+05 | .479000E+04 | 1.00000 |
| 77 | .172000E+05 | .129000E+05 | 14.00000 |
| 78 | .194000E+05 | 0. | 1.00000 |
| 79 | .135400E+05 | .107000E+05 | 1.00000 |
| 80 | .135400E+05 | .704000E+04 | 28.00000 |
| 81 | .117900E+05 | .879000E+04 | 49.00000 |
| 82 | .117900E+05 | .704000E+04 | 1.00000 |
| 83 | .606500E+04 | 0. | 11.00000 |
| 84 | .914600E+04 | .684600E+04 | 4.00000 |
| 85 | .914600E+04 | 0. | 1.00000 |
| 86 | .821500E+04 | .684600E+04 | 1.00000 |
| 87 | .606500E+04 | 0. | 24.00000 |
| 88 | .821500E+04 | 0. | 1.00000 |
| 89 | .914600E+04 | .684600E+04 | 4.00000 |
| 90 | .914600E+04 | 0. | 1.00000 |
| 91 | .606500E+04 | 0. | 11.00000 |

2. <u>5.0g Flight by Flight Spectrum</u>

5.JG FLIGHT BY FLIGHT SPECTRUM

THE NUMBER OF PEAKS OR VALLEYS IN THE INPUT LOAD SPECTRUM = 74

| STEP | SIGMA MAXIMUM | SIGMA MINIMUM | COUNTER K |
|---|---|---|---|
| 1 | .423000E+02 | .277000E+02 | 1.00000 |
| 2 | .493000E+02 | .231000E+02 | 1.00000 |
| 3 | .396000E+02 | .231000E+02 | 1.00000 |
| 4 | .396000E+02 | .231000E+02 | 1.00000 |
| 5 | .493000E+02 | .231000E+02 | 1.00000 |
| 6 | .456000E+02 | .230000E+02 | 1.00000 |
| 7 | .479000E+02 | 0. | 1.00000 |
| 8 | .342000E+02 | 0. | 4.00000 |
| 9 | .283000E+02 | .230000E+02 | 1.00000 |
| 10 | .308000E+02 | .152000E+02 | 1.00000 |
| 11 | .583000E+02 | .230000E+02 | 1.00000 |
| 12 | .308000E+02 | .152000E+02 | 1.00000 |
| 13 | .308000E+02 | .152000E+02 | 1.00000 |
| 14 | .668000E+02 | .230000E+02 | 1.00000 |
| 15 | .456000E+02 | .230000E+02 | 1.00000 |
| 16 | .308000E+02 | .152000E+02 | 2.00000 |
| 17 | .308000E+02 | .152000E+02 | 2.00000 |
| 18 | .490000E+02 | .227000E+02 | 1.00000 |
| 19 | .308000E+02 | .152000E+02 | 1.00000 |
| 20 | .308000E+02 | .152000E+02 | 1.00000 |
| 21 | .345000E+02 | .112000E+02 | 1.00000 |
| 22 | .308000E+02 | .152000E+02 | 1.00000 |
| 23 | .308000E+02 | .152000E+02 | 1.00000 |
| 24 | .299000E+02 | .111000E+02 | 5.00000 |
| 25 | .299000E+02 | .220000E+01 | 4.00000 |
| 26 | .408000E+02 | .116000E+02 | 3.00000 |
| 27 | .504000E+02 | .220000E+01 | 1.00000 |
| 28 | .299000E+02 | .116000E+02 | 7.00000 |
| 29 | .299000E+02 | .220000E+01 | 13.00000 |
| 30 | .299000E+02 | .116000E+02 | 8.00000 |
| 31 | .408000E+02 | .220000E+01 | 5.00000 |
| 32 | .504000E+02 | .116000E+02 | 1.00000 |
| 33 | .408000E+02 | .111000E+02 | 1.00000 |
| 34 | .593000E+02 | .220000E+01 | 1.00000 |
| 35 | .517000E+02 | .203000E+02 | 1.00000 |
| 36 | .402000E+02 | .203000E+02 | 1.00000 |
| 37 | .402000E+02 | .203000E+02 | 1.00000 |
| 38 | .736000E+02 | .203000E+02 | 1.00000 |
| 39 | .778000E+02 | .203000E+02 | 1.00000 |
| 40 | .517000E+02 | .203000E+02 | 1.00000 |
| 41 | .517000E+02 | .203000E+02 | 1.00000 |
| 42 | .648000E+02 | .203000E+02 | 1.00000 |
| 43 | .648000E+02 | .203000E+02 | 1.00000 |
| 44 | .366000E+02 | .198000E+02 | 1.00000 |
| 45 | .366000E+02 | .198000E+02 | 1.00000 |
| 46 | .464000E+02 | .140000E+01 | 1.00000 |
| 47 | .395000E+02 | .104000E+02 | 1.00000 |
| 48 | .395000E+02 | .140000E+01 | 5.00000 |
| 49 | .307000E+02 | .104000E+02 | 11.00000 |
| 50 | .395000E+02 | .104000E+02 | 1.00000 |
| 51 | .498000E+02 | .140000E+01 | 1.00000 |
| 52 | .307000E+02 | .104000E+02 | 6.00000 |
| 53 | .307000E+02 | .140000E+01 | 17.00000 |

| | | | |
|---|---|---|---|
| 54 | .428000E+02 | .200000E+02 | 1.00000 |
| 55 | .502000E+02 | .200000E+02 | 1.00000 |
| 56 | .366000E+02 | .200000E+02 | 1.00000 |
| 57 | .564000E+02 | .200000E+02 | 1.00000 |
| 58 | .470000E+02 | .200000E+02 | 1.00000 |
| 59 | .526000E+02 | .200000E+02 | 1.00000 |
| 60 | .470000E+02 | .200000E+02 | 1.00000 |
| 61 | .254000E+02 | .470000E+01 | 1.00000 |
| 62 | .254000E+02 | -.160000E+01 | 1.00000 |
| 63 | .184000E+02 | -.160000E+01 | 3.00000 |
| 64 | .338000E+02 | .114000E+02 | 1.00000 |
| 65 | .306000E+02 | .151000E+02 | 1.00000 |
| 66 | .306000E+02 | .151000E+02 | 1.00000 |
| 67 | .396000E+02 | .230000E+02 | 1.00000 |
| 68 | .456000E+02 | .228000E+02 | 1.00000 |
| 69 | .306000E+02 | .151000E+02 | 1.00000 |
| 70 | .583000E+02 | .228000E+02 | 1.00000 |
| 71 | .306000E+02 | .151000E+02 | 1.00000 |
| 72 | .583000E+02 | .228000E+02 | 1.00000 |
| 73 | .366000E+02 | .222000E+02 | 1.00000 |
| 74 | .583000E+02 | .294000E+02 | 2.00000 |

STEP NUMBERS OF IDENTICAL PEAKS AND VALLEYS WHICH OCCUR CONSECUTIVELY IN THE LOAD SPECTRUM

4 13 17 20 23 37 41 43 45 66

LOAD SPECTRUM DATA ADJUSTED FOR RANGE PAIR COUNTING = 64

| STEP | SIGMA MAXIMUM | SIGMA MINIMUM | COUNTER K |
|---|---|---|---|
| 1 | .423000E+02 | .277000E+02 | 1.00000 |
| 2 | .493000E+02 | .231000E+02 | 1.00000 |
| 3 | .396000E+02 | .231000E+02 | 2.00000 |
| 5 | .493000E+02 | .231000E+02 | 1.00000 |
| 6 | .456000E+02 | .233000E+02 | 1.00000 |
| 7 | .479000E+02 | 0. | 1.00000 |
| 8 | .342000E+02 | 0. | 4.00000 |
| 9 | .283000E+02 | .230000E+02 | 1.00000 |
| 10 | .308000E+02 | .152000E+02 | 1.00000 |
| 11 | .583000E+02 | .230000E+02 | 1.00000 |
| 12 | .308000E+02 | .152000E+02 | 2.00000 |
| 14 | .668000E+02 | .230000E+02 | 1.00000 |
| 15 | .456000E+02 | .230000E+02 | 1.00000 |
| 16 | .308000E+02 | .152000E+02 | 4.00000 |
| 18 | .490000E+02 | .227000E+02 | 1.00000 |
| 19 | .308000E+02 | .152000E+02 | 2.00000 |
| 21 | .345000E+02 | .112000E+02 | 1.00000 |
| 22 | .308000E+02 | .152000E+02 | 2.00000 |
| 24 | .299000E+02 | .111000E+02 | 5.00000 |
| 25 | .299000E+02 | .220000E+01 | 4.00000 |
| 26 | .468000E+02 | .116000E+02 | 3.00000 |
| 27 | .564000E+02 | .220000E+01 | 1.00000 |
| 28 | .299000E+02 | .116000E+02 | 7.00000 |
| 29 | .299000E+02 | .220000E+01 | 13.00000 |
| 30 | .299000E+02 | .116000E+02 | 8.00000 |
| 31 | .408000E+02 | .223000E+01 | 5.00000 |
| 32 | .564000E+02 | .116000E+02 | 1.00000 |
| 33 | .405000E+02 | .111000E+02 | 1.00000 |
| 34 | .593000E+02 | .220000E+01 | 1.00000 |
| 35 | .517000E+02 | .203000E+02 | 1.00000 |
| 36 | .402000E+02 | .203000E+02 | 2.00000 |
| 38 | .736000E+02 | .203000E+02 | 1.00000 |
| 39 | .778000E+02 | .203000E+02 | 1.00000 |
| 40 | .517000E+02 | .203000E+02 | 2.00000 |
| 42 | .648000E+02 | .203000E+02 | 2.00000 |
| 44 | .366000E+02 | .199000E+02 | 2.00000 |
| 46 | .464000E+02 | .140000E+01 | 1.00000 |
| 47 | .395000E+02 | .104000E+02 | 1.00000 |
| 48 | .395000E+02 | .140000E+01 | 5.00000 |
| 49 | .307000E+02 | .104000E+02 | 11.00000 |
| 50 | .395000E+02 | .104000E+02 | 1.00000 |
| 51 | .498000E+02 | .140000E+01 | 1.00000 |
| 52 | .307000E+02 | .104000E+02 | 6.00000 |
| 53 | .307000E+02 | .140000E+01 | 17.00000 |
| 54 | .428000E+02 | .200000E+02 | 1.00000 |
| 55 | .502000E+02 | .200000E+02 | 1.00000 |
| 56 | .366000E+02 | .200000E+02 | 1.00000 |
| 57 | .564000E+02 | .200000E+02 | 1.00000 |
| 58 | .470000E+02 | .200000E+02 | 1.00000 |
| 59 | .526000E+02 | .200000E+02 | 1.00000 |
| 60 | .470000E+02 | .200000E+02 | 1.00000 |
| 61 | .254000E+02 | .470000E+01 | 1.00000 |
| 62 | .254000E+02 | -.160000E+01 | 1.00000 |
| 63 | .184000E+02 | -.160000E+01 | 3.00000 |
| 64 | .338000E+02 | .114000E+02 | 1.00000 |

| | | | |
|---|---|---|---|
| 65 | .306000E+02 | .151000E+02 | 2.00000 |
| 67 | .396000E+02 | .230000E+02 | 1.00000 |
| 68 | .456000E+02 | .228000E+02 | 1.00000 |
| 69 | .306000E+02 | .151000E+02 | 1.00000 |
| 70 | .583000E+02 | .228000E+02 | 1.00000 |
| 71 | .306000E+02 | .151000E+02 | 1.00000 |
| 72 | .583000E+02 | .228000E+02 | 1.00000 |
| 73 | .366000E+02 | .222000E+02 | 1.00000 |
| 74 | .563000E+02 | .294000E+02 | 2.00000 |

RANGE PAIR CYCLE COUNTED SPECTRUM

| | SIGMA | | |
|---|---|---|---|
| STEP | MAXIMUM | MINIMUM | COUNTER K |
| 1 | .423000E+02 | .277000E+02 | 1.00000 |
| 2 | .493000E+02 | 0. | 1.00000 |
| 3 | .396000E+02 | .231000E+02 | 2.00000 |
| 4 | .493000E+02 | .231000E+02 | 1.00000 |
| 5 | .456000E+02 | .231000E+02 | 1.00000 |
| 6 | .479000E+02 | .230000E+02 | 1.00000 |
| 7 | .342000E+02 | 0. | 4.00000 |
| 8 | .283000E+02 | .230000E+02 | 1.00000 |
| 9 | .308000E+02 | .152000E+02 | 1.00000 |
| 10 | .583000E+02 | .152000E+02 | 1.00000 |
| 11 | .308000E+02 | .230000E+02 | 1.00000 |
| 12 | .308000E+02 | .152000E+02 | 1.00000 |
| 13 | .668000E+02 | .220000E+01 | 1.00000 |
| 14 | .456000E+02 | .230000E+02 | 1.00000 |
| 15 | .308000E+02 | .230000E+02 | 1.00000 |
| 16 | .308000E+02 | .152000E+02 | 3.00000 |
| 17 | .490000E+02 | .152000E+02 | 1.00000 |
| 18 | .308000E+02 | .227000E+02 | 1.00000 |
| 19 | .308000E+02 | .152000E+02 | 1.00000 |
| 20 | .345000E+02 | .152000E+02 | 1.00000 |
| 21 | .308000E+02 | .152000E+02 | 1.00000 |
| 22 | .308000E+02 | .112000E+02 | 1.00000 |
| 23 | .299000E+02 | .152000E+02 | 1.00000 |
| 24 | .299000E+02 | .111000E+02 | 5.00000 |
| 25 | .299000E+02 | .220000E+01 | 3.00000 |
| 26 | .408000E+02 | .116000E+02 | 3.00000 |
| 27 | .564000E+02 | .220000E+01 | 1.00000 |
| 28 | .299000E+02 | .116000E+02 | 7.00000 |
| 29 | .299000E+02 | .220000E+01 | 13.00000 |
| 30 | .299000E+02 | .116000E+02 | 8.00000 |
| 31 | .408000E+02 | .220000E+01 | 5.00000 |
| 32 | .534000E+02 | .111000E+02 | 1.00000 |
| 33 | .408000E+02 | .116000E+02 | 1.00000 |
| 34 | .593000E+02 | .220000E+01 | 1.00000 |
| 35 | .517000E+02 | .203000E+02 | 1.00000 |
| 36 | .402000E+02 | .203000E+02 | 2.00000 |
| 37 | .736000E+02 | .203000E+02 | 1.00000 |
| 38 | .778000E+02 | -.160000E+01 | 1.00000 |
| 39 | .517000E+02 | .203000E+02 | 2.00000 |
| 40 | .648000E+02 | .203000E+02 | 2.00000 |
| 41 | .366000E+02 | .203000E+02 | 1.00000 |
| 42 | .356000E+02 | .198000E+02 | 1.00000 |
| 43 | .464000E+02 | .198000E+02 | 1.00000 |
| 44 | .395000E+02 | .104000E+02 | 1.00000 |
| 45 | .295000E+02 | .140000E+01 | 5.00000 |
| 46 | .307000E+02 | .104000E+02 | 11.00000 |
| 47 | .395000E+02 | .104000E+02 | 1.00000 |
| 48 | .498000E+02 | .140000E+01 | 1.00000 |
| 49 | .307000E+02 | .104000E+02 | 6.00000 |
| 50 | .307000E+02 | .140000E+01 | 17.00000 |
| 51 | .428000E+02 | .200000E+02 | 1.00000 |
| 52 | .502000E+02 | .200000E+02 | 1.00000 |
| 53 | .366000E+02 | .200000E+02 | 1.00000 |
| 54 | .564000E+02 | .140000E+01 | 1.00000 |
| 55 | .470000E+02 | .200000E+02 | 1.00000 |

| | | | |
|---|---|---|---|
| 56 | .526000E+02 | .200000E+02 | 1.00000 |
| 57 | .470000E+02 | .200000E+02 | 1.00000 |
| 58 | .254000E+02 | .200000E+02 | 1.00000 |
| 59 | .254000E+02 | .470000E+01 | 1.00000 |
| 60 | .184000E+02 | -.160000E+01 | 3.00000 |
| 61 | .338000E+02 | .114000E+02 | 1.00000 |
| 62 | .336000E+02 | .151000E+02 | 2.00000 |
| 63 | .396000E+02 | .230000E+02 | 1.00000 |
| 64 | .456000E+02 | .151000E+02 | 1.00000 |
| 65 | .306000E+02 | .228000E+02 | 2.00000 |
| 66 | .583000E+02 | .151000E+02 | 1.00000 |
| 67 | .583000E+02 | .222000E+02 | 1.00000 |
| 68 | .366000E+02 | .228000E+02 | 1.00000 |
| 69 | .503000E+02 | .294000E+02 | 2.00000 |

## APPENDIX II

## PROGRAM LISTING

```
      PROGRAM RPCM(INPUT,TAPE5=INPUT,OUTPUT,TAPE6=OUTPUT,PUNCH)
C
C     THIS PROGRAM EMPLOYS THE RANGE PAIR CYCLE COUNTING METHOD TO GENERATE AN
C     ANALYSIS SPECTRUM FROM A GIVEN LOAD SPECTRUM
C
C     INPUT
C     CARD 1.                TITLE = DESCRIPTION OF THE INPUT LOAD SPECTRUM, S
C                            FORMAT 8A10
C     CARD 2.                NPKS = NUMBER OF PEAKS OR VALLEYS IN THE
C                                   LOAD SPECTRUM
C                            NPUNCH = PUNCH FLAG SUCH THAT NPUNCH
C                                     NOT EQUAL TO ZERO IMPLIES PUNCH
C                                     THE RANGE PAIR COUNTED SPECTRUM
C                                     IN THE INPUT FORMAT
C                            FORMAT 2I5
C     CARDS 3,...,NPKS+2.    SIGMAX(I) = ITH PEAK OF THE LOAD SPECTRUM
C                            SIGMIN(I) = ITH VALLEY OF THE LOAD SPECTRUM
C                            RNCYC(I) = COUNTER K OF THE ITH PEAK AND VALLEY
C                            FORMAT 5X,3E10.0
C
C                               PROGRAM ARRAYS
C                 (INFORMATION NEEDED TO CHANGE DIMENSIONS)
C
C     ARRAY NAME             DEFINITION                       DIMENSION
C       SIGMAX      PEAKS OF THE INPUT LOAD SPECTRUM         NPKS + KK
C             KK =  THE NUMBER OF ADDITIONAL CYCLES (EXCLUDING INPUT CYCLES)
C                   WHICH THE PROGRAM WILL GENERATE
C       SIGMIN      VALLEYS OF THE INPUT LOAD SPECTRUM       NPKS + KK
C       RNCYC       K COUNTERS OF THE PEAKS AND VALLEYS      NPKS + KK
C       NSTEP       STEP NUMBERS OF THE INPUT SPECTRUM       NPKS + KK
C       RES         RESIDUE SPECTRUM                          2*NPKS
C       INDEX       STEP NUMBERS OF ELEMENTS IN RES           2*NPKS
C       CYCLE       RANGE PAIR COUNTED CYCLES                NPKS + KK
C       RNECYC      K COUNTERS OF THE CYCLES OF THE          NPKS + KK
C                   UNSORTED ANALYSIS SPECTRUM
C       NNSTEP      STEP NUMBERS OF ELEMENTS OF THE          NPKS + KK
C                   UNSORTED ANALYSIS SPECTRUM
C       ISAVE       VALUES OF NSTEP(J) SUCH THAT RNCYC(J)        99
C                   IS < 1.0 AND VALUES OF NSTEP(J) SUCH
C                   THAT SIGMAX(J-1) = SIGMAX(J) AND
C                   SIGMIN(J-1) = SIGMIN(J)
C
C
      COMMON/MDEC/SIGMAX(900),SIGMIN(900),NSTEP(900),LR,KMAX,KMIN,K31
      COMMON/MDECR/RES(1400),INDEX(1400),IND1,IND2,IND3,IND4,KIND
      COMMON/MCYG/CYCLE(900,2),RNECYC(900),NNSTEP(900)
      COMMON/MCGDE/L,LIND
      DIMENSION RNCYC(900),ISAVE(99),TITLE(8)
 9999 NPUNCH = 0
      READ(5,18) (TITLE(I), I = 1,8)
      IF (EOF(5))9000,9100
   18 FORMAT(8A10)
 9000 STOP
 9100 READ(5,95) NPKS,NPUNCH
   95 FORMAT(14I5)
```

```
      READ(5,101) (SIGMAX(I),SIGMIN(I),RNCYC(I), I = 1,NPKS)
  101 FORMAT(5X,3E10.3)
      DO 8000 I = 1,NPKS
 8000 NSTEP(I) = I
      WRITE(6,19) (TITLE(I), I = 1,8)
   19 FORMAT(1H1,8A10)
      WRITE(6,20) NPKS
   20 FORMAT(1H0,60HTHE NUMBER OF PEAKS OR VALLEYS IN THE INPUT LOAD SPE
     1CTRUM = ,I5//)
      WRITE(6,22)
   22 FORMAT(60X,5HSIGMA/31X,4HSTEP,13X,7HMAXIMUM,16X,7HMINIMUM,13X,
     1        9HCCUNTER K/)
      WRITE(6,25) (NSTEP(I),SIGMAX(I),SIGMIN(I),RNCYC(I), I = 1,NPKS)
   25 FORMAT(29X,I5,10X,E13.6,10X,E13.6,10X,F10.5)
C
C     SORT THROUGH THE LOAD SPECTRUM - PULL OUT THOSE PEAKS AND VALLEYS WHOSE
C     COUNTER K IS LESS THAN 1.0
C
      J = 1
      L = 0
      NPES = 1
      NCYNO = 100
      JMAX = 0
      DO 100 I = 1,NPKS
      IF (RNCYC(I) .GE. 1.0) GO TO 100
      X1 = SIGMAX(I)
      X2 = SIGMIN(I)
      CALL CYCGEN(X1,X2  ,RNCYC(I),NSTEP(I))
      ISAVE(J) = I
      J = J + 1
  100 CONTINUE
      JMAX = J - 1
      NPKSN = NPKS - JMAX
      IF (JMAX .EQ. 0) GO TO 200
      WRITE(6,23) (ISAVE(K), K = 1,JMAX)
   23 FORMAT(1H0,93HSTEP NUMBERS OF THOSE PEAKS AND VALLEYS IN THE LOAD
     1SPECTRUM WHOSE COUNTER K IS LESS THAN 1.0//(17I7))
      DO 110 J = 1,JMAX
      I = ISAVE(J) - (J-1)
      NPKN = NPKS - J
      IF (I .EQ. NPKN) GO TO 110
      DO 115 II = I,NPKN
      SIGMAX(II) = SIGMAX(II+1)
      SIGMIN(II) = SIGMIN(II+1)
      NSTEP(II) = NSTEP(II+1)
      RNCYC(II) = RNCYC(II+1)
  115 CONTINUE
  110 CONTINUE
      WRITE(6,24) NPKSN
      WRITE(6,22)
      WRITE(6,25) (NSTEP(I),SIGMAX(I),SIGMIN(I),RNCYC(I), I = 1,NPKSN)
  200 CONTINUE
C
C     SORT THROUGH THE LOAD SPECTRUM DATA - COMBINE STEPS WITH IDENTICAL PEAKS
C     AND VALLEYS WHICH OCCUR CONSECUTIVELY
```

```
C
      J = 1
      DO 300 I = 2,NPKSN
      IF (SIGMAX(I) .NE. SIGMAX(I-1)) GO TO 300
      IF (SIGMIN(I) .NE. SIGMIN(I-1)) GO TO 300
      ISAVE(J) = I
      RNCYC(I-1) = RNCYC(I-1) + RNCYC(I)
      J = J + 1
  300 CONTINUE
      IF (J .EQ. 1) GO TO 6000
      JMAS = J - 1
      WRITE(6,26) (ISAVE(K), K = 1,JMAS)
   26 FORMAT(1H0,90HSTEP NUMBERS OF IDENTICAL PEAKS AND VALLEYS WHICH OC
     1CUR CONSECUTIVELY IN THE LOAD SPECTRUM//(17I7))
      DO 311 J = 1,JMAS
      I = ISAVE(J) - (J-1)
      NPKN = NPKSN - J
      IF (I .EQ. NPKN) GO TO 311
      DO 316 II = I,NPKN
      SIGMAX(II) = SIGMAX(II+1)
      SIGMIN(II) = SIGMIN(II+1)
      NSTEP(II) = NSTEP(II+1)
      RNCYC(II) = RNCYC(II+1)
  316 CONTINUE
  311 CONTINUE
      NPKSN = NPKSN - JMAS
      WRITE(6,24) NPKSN
   24 FORMAT(1H1,54HLOAD SPECTRUM DATA ADJUSTED FOR RANGE PAIR COUNTING
     1= ,I5//)
      WRITE(6,22)
      WRITE(6,25) (NSTEP(I),SIGMAX(I),SIGMIN(I),RNCYC(I), I = 1,NPKSN)
C
C     RANGE PAIR COUNT THE ADJUSTED LOAD SPECTRUM
C
 6000 I = 1
      KB = 0
      L = JMAX
      KMIN = 0
      KMAX = 0
      LR = 0
      K31 = 0
    1 IF (RNCYC(I) .GT. 1.0) GO TO 400
      IF (KB .NE. 0) GO TO 5
      X1 = SIGMAX(I)
      X2 = SIGMIN(I)
      IND1 = NSTEP(I)
      IND2 = IND1
      I = I + 1
      KB = 1
      GO TO 1
    5 X3 = SIGMAX(I)
      X4 = SIGMIN(I)
      IND3 = NSTEP(I)
      IND4 = IND3
      KMIN = 1
```

```
      KMAX = 0
      K31 = 0
      IF (RNCYC(I) .EQ. 1.0) GO TO 5
      KEY = 1
      KIND = 1
      GO TO 415
    6 KEY = 0
      CYCNO = RNCYC(I)
      CALL DECIDE(X1,X2,X3,X4,KEY,I,CYCNO,KCYGEN)
 1000 GO TO (10,10,30),KCYGEN
   10 KB = 1
      IF (KMIN .NE. 1) GO TO 36
      I = I + 1
      IF (I .LE. NPKSN) GO TO 5
      RES(LR+1) = X1
      RES(LR+2) = X2
      INDEX(LR+1) = IND1
      INDEX(LR+2) = IND2
      LRMAX = LR + 2
      GO TO 2000
   30 IF (KMIN .NE. 1) GO TO 35
   12 I = I + 1
      IF (I .LE. NPKSN) GO TO 31
      RES(LR+1) = X1
      RES(LR+2) = X2
      RES(LR+3) = X3
      INDEX(LR+1) = IND1
      INDEX(LR+2) = IND2
      INDEX(LR+3) = IND3
      LRMAX = LR + 3
      GO TO 2000
   31 X4 = SIGMAX(I)
      IND4 = NSTEP(I)
      KMAX = 1
      KMIN = 0
      K31 = 1
   32 IF (RNCYC(I) .GT. 1.0) GO TO 40
      GO TO 6
   40 KEY = 1
      KIND = 0
      GO TO 415
   35 X4 = SIGMIN(I)
      IND4 = NSTEP(I)
      KMIN = 1
      KMAX = 0
      K31 = 0
      GO TO 32
   36 X3 = SIGMIN(I)
      IND3 = NSTEP(I)
      KMIN = 1
      KMAX = 0
      GO TO 12
  400 KEY = 1
      IF (KB .NE. 0) GO TO 410
      X1 = SIGMAX(I)
```

```
      X2 = SIGMIN(I)
      X3 = SIGMAX(I)
      X4 = SIGMIN(I)
      IND1 = NSTEP(I)
      IND2 = IND1
      IND3 = IND1
      IND4 = IND1
      KMIN = 1
      KMAX = 0
      K31 = 0
      IF (RNCYC(I) .LE. 2.0) GO TO 401
      RNCYC(I) = RNCYC(I) - 1.0
      GO TO 402
  401 RNCYC(I) = RNCYC(I) - 2.0
  402 KIND = 0
      GO TO 415
  410 X3 = SIGMAX(I)
      X4 = SIGMIN(I)
      IND3 = NSTEP(I)
      IND4 = IND3
      KMIN = 1
      KMAX = 0
      K31 = 0
      KIND = 1
      RNCYC(I) = RNCYC(I) - 1.0
      KB = 0
  415 CYCNO = RNCYC(I)
      CALL DECIDE(X1,X2,X3,X4,KEY,I,CYCNO,KCYGEN)
      GO TO 1000
 2000 LMAX = L
      WRITE(6,2001) NRES,LRMAX
 2001 FORMAT(1H1,27HMEMBERS OF RESIDUE SPECTRUM,I5,3H = , I5//,55X,
     15HVALUE,16X,4HSTEP//)
      WRITE(6,2002) (RES(J),INDEX(J), J = 1,LRMAX)
 2002 FORMAT(50X,E15.6,10X,I5)
      WRITE(6,2003) NRES,LMAX
 2003 FORMAT(1H1,40HCYCLES GENERATED BEFORE RESIDUE SPECTRUM,I5,3H = ,
     1I5//)
      WRITE(6,22)
      WRITE(6,25)    (NNSTEP(I),CYCLE(I,1),CYCLE(I,2),RNECYC(I),
     1               I = 1,LMAX)
      IF (LRMAX .LT. 4) GO TO 5000
      IF (NCYNO .EQ. 0) GO TO 5000
C
C     RANGE PAIR COUNT OF RESIDUE SPECTRUMS
C
      NRES = NRES + 1
      CALL DECRES(LRMAX,NCYNO)
      GO TO 2000
 5000 IF (LRMAX .LE. 1) GO TO 3000
C
C     COUNT THE LAST RESIDUE SPECTRUM - RANGE PAIR COUNTING WILL YIELD NO
C     ADDITIONAL CYCLES
C
      KK = 0
```

```
      RESMAX = RES(1)
      RESMIN = RES(1)
      IMAX = 1
      IMIN = 1
      DO 500 I = 2,LRMAX
      IF (RES(I) .LT. RESMAX) GO TO 490
      RESMAX = RES(I)
      IMAX = I
      GO TO 500
  490 IF (RES(I) .GT. RESMIN) GO TO 500
      RESMIN = RES(I)
      IMIN = I
  500 CONTINUE
      CALL CYCRES(RESMAX,RESMIN,1.0,INDEX(IMAX))
      KK = KK + 1
  510 J = IMAX - 2
      IF (J .LE. 0) GO TO 550
      CALL CYCRES(RES(J),RES(J+1),1.0,INDEX(J))
      KK = KK + 1
      IMAX = J
      GO TO 510
  550 J = IMIN + 2
      IF (J .GT. LRMAX) GO TO 575
      CALL CYCRES(RES(J-1),RES(J),1.0,INDEX(J-1))
      KK = KK + 1
      IMIN = J
      GO TO 550
  575 KMAX = KK
      LMAX = L
      WRITE(6,2005) KMAX
 2005 FORMAT(1H1,71HCYCLES GENERATED FROM LAST RESIDUE SPECTRUM - NO RAN
     1GE PAIR COUNTING = ,I5)
      WRITE(6,22)
      WRITE(6,25) (NNSTEP(I),CYCLE(I,1),CYCLE(I,2),RNECYC(I),
     1              I = 1,LMAX)
C
C     SORT THE ANALYSIS SPECTRUM TO PRODUCE THE RANGE PAIR COUNTED SPECTRUM
C
 3000 KP = 0
      DO 605 JJ = 1,NPKS
      KC = 0
      DO 600 I = 1,LMAX
      IF (NNSTEP(I) .NE. JJ) GO TO 600
      KP = KP + 1
      KC = KC + 1
      NSTEP(KP) = KP
      SIGMAX(KP) = CYCLE(I,1)
      SIGMIN(KP) = CYCLE(I,2)
      RNCYC(KP) = RNECYC(I)
      IF (KC .LT. 2) GO TO 600
      IF (SIGMAX(KP) .NE. SIGMAX(KP-1)) GO TO 600
      IF (SIGMIN(KP) .NE. SIGMIN(KP-1)) GO TO 600
  595 KP = KP - 1
      RNCYC(KP) = RNCYC(KP) + 1.0
  600 CONTINUE
```

```
  605 CONTINUE
      KPMAX = KP
      WRITE(6,2010)
 2010 FORMAT(1H1,48X,33HRANGE PAIR CYCLE COUNTED SPECTRUM//)
      WRITE(6,22)
      WRITE(6,25) (NSTEP(I),SIGMAX(I),SIGMIN(I),RNCYC(I),I = 1,KPMAX)
      IF (NPUNCH .EQ. 0) GO TO 9999
      PUNCH 102, (SIGMAX(I),SIGMIN(I),RNCYC(I), I = 1,KPMAX)
  102 FORMAT(5X,3F10.2)
      GO TO 9999
      END
```

```
      SUBROUTINE DECIDE(X1,X2,X3,X4,KEY,I,CYCNO,KCYGEN)
      COMMON/MDEC/SIGMAX(900),SIGMIN(900),NSTEP(900),LR,KMAX,KMIN,K31
      COMMON/MDECR/RES(1400),INDEX(1400),IND1,IND2,IND3,IND4,KIND
      COMMON/MCYG/CYCLE(900,2),RNECYC(900),NNSTEP(900)
      COMMON/MCGDE/L,LIND
C
C     THIS SUBROUTINE DECIDES WHETHER OR NOT THE VALUES X1,X2,X3, AND X4
C     FROM THE ADJUSTED LOAD SPECTRUM SATISFY THE RANGE PAIR COUNTING CONDITIONS
C
      KFIRST = 0
      IF (K31 .NE. 0) GO TO 11
   10 IF (X3 .LE. X2) GO TO 200
   11 IF (X2 .GT. X1) GO TO 210
      IF (X2 .LT. X4 .OR. X3 .GT. X1) GO TO 500
  150 IF (X2 .GT. X3) GO TO 151
      CALL CYCGEN(X3,X2,1.0,NSTEP(I))
      GO TO 152
  151 CALL CYCGEN(X2,X3,  1.0,NSTEP(I))
  152 X1 = X1
      X2 = X4
      IF (IND3 .NE. IND2) LIND = 1
      IND2 = IND4
      KCYGEN = 1
      IF (KEY .NE. 0) GO TO 110
      RETURN
  210 IF (X2 .GT. X4 .OR. X3 .LT. X1) GO TO 500
      GO TO 150
  200 X1 = X1
      X2 = X4
      IND2 = IND4
      KCYGEN = 2
      IF (KEY .EQ. 0) RETURN
      CYCNO = CYCNO - 1.0
      GO TO 110
C
C     ADD X1 TO THE RESIDUE SPECTRUM
C
  500 LR = LR + 1
      RES(LR) = X1
      INDEX(LR) = IND1
      X1 = X2
      X2 = X3
      X3 = X4
      IND1 = IND2
      IND2 = IND3
      IND3 = IND4
      KCYGEN = 3
      IF (KEY .NE. 0) GO TO 110
      RETURN
  110 GO TO (1150,1200,1500),KCYGEN
 1150 IF (CYCNO .GT. 1.0) GO TO 1151
      IF (CYCNO .EQ. 0.0) RETURN
 1153 CYCNO = CYCNO - 1.0
      GO TO 1152
 1151 IF (LIND .EQ. 1) GO TO 1153
```

```
      IF (IND3 .NE. IND4) GO TO 1153
      RNECYC(L) = RNECYC(L) + CYCNO - 2.0
      CYCNO = 1.0
 1152 IF (KMAX .NE. 1) GO TO 111
      X3 = SIGMIN(I)
      IND3 = NSTEP(I)
      IF (CYCNO .NE. 0.0) GO TO 112
      KMIN = 1
      KMAX = 0
      KCYGEN = 3
      RETURN
 1200 IF (CYCNO .EQ. 0.0) RETURN
      CYCNO = CYCNO - 1.0
      X3 = SIGMAX(I)
      X4 = SIGMIN(I)
      KFIRST = 1
      GO TO 113
  111 X3 = SIGMAX(I)
      X4 = SIGMIN(I)
      IF (KFIRST .NE. 0) GO TO 113
      CYCNO = CYCNO - 1.0
      KFIRST = 1
  113 IND3 = NSTEP(I)
      IND4 = IND3
      KMIN = 1
      KMAX = 0
      GO TO 10
 1500 IF (KMAX .NE. 0) GO TO 1510
      IF (CYCNO .EQ. 0.0) RETURN
      CYCNO = CYCNO - 1.0
  112 X4 = SIGMAX (I)
      IND4 = NSTEP(I)
      KMAX = 1
      KMIN = 0
      GO TO 11
 1510 X4 = SIGMIN(I)
      IND4 = NSTEP(I)
      KMAX = 0
      KMIN = 1
      GO TO 10
      END
```

```
      SUBROUTINE CYCGEN(Y1,Y2,  CYCPF,NSTEPP)
      COMMON/MCYG/CYCLE(900,2),RNECYC(900),NNSTEP(900)
      COMMON/MCGDE/L,LIND
C
C     THIS SUBROUTINE GENERATES CYCLES FOR THE ANALYSIS SPECTRUM FROM DATA
C     SUPPLIED BY SUBROUTINE DECIDE
C
      LIND = 0
      L = L + 1
      CYCLE(L,1) = Y1
      CYCLE(L,2) = Y2
      RNECYC(L) = CYCPF
      NNSTEP(L) = NSTEPP
      IF (L .EQ. 1) GO TO 100
      IF (CYCLE(L-1,1) .NE. CYCLE(L,1)) GO TO 100
      IF (CYCLE(L-1,2) .NE. CYCLE(L,2)) GO TO 100
   10 L = L - 1
      RNECYC(L) = RNECYC(L) + 1.0
      LIND = 1
  100 RETURN
      END
```

```
      SUBROUTINE DECRES(LRMAX,NCYNO)
      COMMON/MCODE/L,LIND
      COMMON/MDECR/RES(1400),INDEX(1400),IND1,IND2,IND3,IND4,KIND
C
C     THIS SUBROUTINE DECIDES WHETHER OR NOT THE ELEMENTS OF THE RESIDUE
C     SPECTRUM SATISFY THE RANGE PAIR COUNTING CONDITIONS
C
      K = 0
      NCYNO = 0
      X1 = RES(1)
      X2 = RES(2)
      X3 = RES(3)
      X4 = RES(4)
      IND1 = INDEX(1)
      IND2 = INDEX(2)
      IND3 = INDEX(3)
      IND4 = INDEX(4)
      J = 4
   10 IF (X2 .GT. X1) GO TO 100
      IF (X2 .LT. X4 .OR. X3 .GT. X1) GO TO 500
  150 IF (X2 .GT. X3) GO TO 151
      CALL CYCRES(X3,X2,1.0,IND3)
      GO TO 152
  151 CALL CYCRES(X2,X3,1.0,IND2)
  152 NCYNO = NCYNO + 1
      X1 = X1
      X2 = X4
      IND2 = IND4
      IF (J .EQ. LRMAX) GO TO 300
      IF ((J + 1) .EQ. LRMAX) GO TO 315
      X3 = RES(J+1)
      X4 = RES(J+2)
      IND3 = INDEX(J+1)
      IND4 = INDEX(J+2)
      J = J+2
      GO TO 10
  100 IF (X2 .GT. X4 .OR. X3 .LT. X1) GO TO 500
      GO TO 150
  500 K = K + 1
      RES(K) = X1
      INDEX(K) = IND1
      J = J + 1
      IF (J .GT. LRMAX) GO TO 330
      X1 = X2
      X2 = X3
      X3 = X4
      X4 = RES(J)
      IND1 = IND2
      IND2 = IND3
      IND3 = IND4
      IND4 = INDEX(J)
      GO TO 10
  300 K = K + 1
      RES(K) = X1
      RES(K+1) = X2
```

```
      INDEX(K) = IND1
      INDEX(K+1) = IND2
      LRMAX = K + 1
      RETURN
  315 K = K + 1
      RES(K) = X1
      RES(K+1) = X2
      RES(K+2) = RES(J+1)
      INDEX(K) = IND1
      INDEX(K+1) = IND2
      INDEX(K+2) = INDEX(J+1)
      LRMAX = K + 2
      RETURN
  330 K = K + 1
      RES(K) = X2
      RES(K+1) = X3
      RES(K+2) = X4
      INDEX(K) = IND2
      INDEX(K+1) = IND3
      INDEX(K+2) = IND4
      LRMAX = K + 2
      RETURN
      END
```

```
      SUBROUTINE CYCRES(Y1,Y2,  CYCPF,NSTEPP)
      COMMON/MCYG/CYCLE(900,2),RNECYC(900),NNSTEP(900)
      COMMON/MCGDE/L,LIND
C
C     THIS SUBROUTINE GENERATES CYCLES FOR THE ANALYSIS SPECTRUM FROM DATA
C     SUPPLIED BY SUBROUTINE DECRES
C
      L = L + 1
      CYCLE(L,1) = Y1
      CYCLE(L,2) = Y2
      RNECYC(L) = CYCPF
      NNSTEP(L) = NSTEPP
      RETURN
      END
```